2014 National Emissions Inventory, version 2 Technical Support Document

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Technical Support Document

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Office of Air Quality Planning and Standards
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Contents

List of Tables

List of Figures

Acronyms and Chemical Notations

AERR	Air Emissions Reporting Rule
APU	Auxiliary power unit
BEIS	Biogenics Emissions Inventory System
C1	Category 1 (commercial marine vessels)
C2	Category 2 (commercial marine vessels)
C3	Category 3 (commercial marine vessels)
CAMD	Clean Air Markets Division (of EPA Office of Air and Radiation)
CAP	Criteria Air Pollutant
CBM	Coal bed methane
CDL	Cropland Data Layer
CEC	North American Commission for Environmental Cooperation
CEM	Continuous Emissions Monitoring
CENRAP	Central Regional Air Planning Association
CERR	Consolidated Emissions Reporting Rule
CFR	Code of Federal Regulations
CH_4	Methane
CHIEF	Clearinghouse for Inventories and Emissions Factors
CMU	Carnegie Mellon University
CMV	Commercial marine vessels
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CSV	Comma Separated Variable
dNBR	Differenced normalized burned ratio
E10	10% ethanol gasoline
EDMS	Emissions and Dispersion Modeling System
EF	emission factor
EGU	Electric Generating Utility
EIS	Emission Inventory System
EAF	Electric arc furnace
EF	Emission factor
EI	Emissions Inventory
EIA	Energy Information Administration
EMFAC	Emission FACtor (model) – for California
EPA	Environmental Protection Agency
ERG	Eastern Research Group
ERTAC	Eastern Regional Technical Advisory Committee
FAA	Federal Aviation Administration
FACTS	Forest Service Activity Tracking System
FCCS	Fuel Characteristic Classification System
FETS	Fire Emissions Tracking System
FWS	United States Fish and Wildlife Service
FRS	Facility Registry System

GHG	Greenhouse gas
GIS	Geographic information systems
GPA	Geographic phase-in area
GSE	Ground support equipment
HAP	Hazardous Air Pollutant
HCl	Hydrogen chloride (hydrochloric acid)
Hg	Mercury
HMS	Hazard Mapping System
ICR	Information collection request
I/M	Inspection and maintenance
IPM	Integrated Planning Model
KMZ	Keyhole Markup Language, zipped (used for displaying data in Google Earth
LRTAP	Long-range Transboundary Air Pollution
LTO	Landing and takeoff
LPG	Liquified Petroleum Gas
MARAMA	Mid-Atlantic Regional Air Management Association
MATS	Mercury and Air Toxics Standards
MCIP	Meteorology-Chemistry Interface Processor
MMT	Manure management train
MOBILE6	Mobile Source Emission Factor Model, version 6
MODIS	Moderate Resolution Imaging Spectroradiometer
MOVES	Motor Vehicle Emissions Simulator
MW	Megawatts
MWC	Municipal waste combustors
NAA	Nonattainment area
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Classification System
NARAP	North American Regional Action Plan
NASF	National Association of State Foresters
NASS	USDA National Agriculture Statistical Service
NATA	National Air Toxics Assessment
NCD	National County Database
NEEDS	National Electric Energy Data System (database)
NEI	National Emissions Inventory
NESCAUM	Northeast States for Coordinated Air Use Management
NFEI	National Fire Emissions Inventory
NG	Natural gas
NH_3	Ammonia
NMIM	National Mobile Inventory Model
NO	Nitrous oxide
NO_2	Nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NO_X	Nitrogen oxides
O_3	Ozone
OAQPS	Office of Air Quality Standards and Planning (of EPA)
OEI	Office of Environmental Information (of EPA)

ORIS	Office of Regulatory Information Systems
OTAQ	Office of Transportation and Air Quality (of EPA)
PADD	Petroleum Administration for Defense Districts
PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
PCB	Polychlorinated biphenyl
PM	Particulate matter
PM25-CON	Condensable $PM_{2.5}$
PM25-FIL	Filterable $PM_{2.5}$
PM25-PRI	Primary $PM_{2.5}$ (condensable plus filterable)
$PM_{2.5}$	Particulate matter 2.5 microns or less in diameter
PM_{10}	Particular matter 10 microns or less in diameter
PM10-FIL	Filterable PM_{10}
PM10-PRI	Primary PM_{10}
POM	Polycyclic organic matter
POTW	Publicly Owned Treatment Works
PSC	Program system code (in EIS)
RFG	Reformulated gasoline
RPD	Rate per distance
RPP	Rate per profile
RPV	Rate per vehicle
RVP	Reid Vapor Pressure
Rx	Prescribed (fire)
SCC	Source classification code
SEDS	State Energy Data System
SFv1	SMARTFIRE version 1
SFv2	SMARTFIRE version 2
S/L/T	State, local, and tribal (agencies)
SMARTFIRE	Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SO_4	Sulfate
TAF	Terminal Area Forecasts
TEISS	Tribal Emissions Inventory Software Solution
TRI	Toxics Release Inventory
UNEP	United Nations Environment Programme
USDA	United States Department of Agriculture
VMT	Vehicle miles traveled
VOC	Volatile organic compounds
USFS	United States Forest Service
WebFIRE	Factor Information Retrieval System
WFU	Wildland fire use
WLF	Wildland fire
WRAP	Western Regional Air Partnership
WRF	Weather Research and Forecasting Model

1 Introduction

1.1 What data are included in the 2014 NEI, Version 2?

The 2014 National Emissions Inventory (NEI), version 2, hereafter referred to as the "2014 NEI" or "2014v2" when version number is important to note, is a national compilation of criteria air pollutant (CAP) and hazardous air pollutant (HAP) emissions. These data are collected from state, local, and tribal (S/L/T) air agencies and the Environmental Protection Agency (EPA) emissions programs including the Toxics Release Inventory (TRI), the Acid Rain Program, and Maximum Achievable Control Technology (MACT) standards development. The 2014v2 is synonymous with "2014 NEI" and replaces version 1 of the 2014 NEI released in December, 2016. This document discusses all components of the NEI, and highlights differences in version 2 over those in version 1 where necessary. The NEI program develops datasets, blends data from these multiple sources, and performs data processing steps that further enhance, quality assure, and augment the compiled data.

The emissions data in the NEI are compiled at different levels of granularity, depending on the data category. For point sources (in general, large facilities), emissions are inventoried at a process-level within a facility. For nonpoint sources (typically smaller, yet pervasive sources) and mobile sources (both onroad and nonroad), emissions are given as county totals. For marine vessel and railroad in-transit sources, emissions are given at the sub-county polygon shape-level. For wildfires and prescribed burning, the data are compiled as day-specific, coordinate-specific (similar to point) events in the "event" portion of the inventory, and these emission estimates are further stratified by smoldering and flaming components.

The pollutants included in the NEI are the pollutants associated with the National Ambient Air Quality Standards (NAAQS), known as CAPs, as well as HAPs associated with EPA's Air Toxics Program. The CAPs have ambient concentration limits or are precursors for pollutants with such limits from the NAAQS program. These pollutants include lead (Pb), carbon monoxide (CO), nitrogen oxides (NO_X), volatile organic compounds (VOCs), sulfur dioxide (SO_2), particulate matter 10 microns or less (PM_{10}), particulate matter 2.5 microns or less ($PM_{2.5}$), and ammonia (NH_3), which is technically not a CAP, but an important PM precursor. The HAP pollutants include the 187 remaining HAP pollutants (methyl ethyl ketone was removed) from the original 188 listed in Section 112(b) of the 1990 Clean Air Act Amendments[1]. There are many different types of HAPs. For example, some are acid gases such as hydrochloric acid (HCl); others are heavy metals such as mercury (Hg), nickel and cadmium; and others are organic compounds such as benzene, formaldehyde, and acetaldehyde. Greenhouse gases (GHGs) are included in the NEI for fires and mobile sources only.

1.2 What is included in this documentation?

This technical support document (TSD) provides a central reference for the 2014 NEI. The primary purpose of this document is to explain the sources of information included in the inventory. This includes showing the sources of data and types of sources that are used for each data category, and then providing more information about the EPA-created components of the data.After the introductory material included in this section, Section 2 explains the source categories and/or sectors that we use for summarizing the 2014 NEI and for organizing this document, and it provides an overview of the contents of the inventory and a summary of mercury emissions. Section 3 provides an overview of point sources. Section 4 provides information about nonpoint sources, including descriptions by source category or sector of the EPA emission estimates and tools. Sections 5 and 6

[1] The original of HAPs is available on the EPA Technology Transfer Network – Air Toxics Web Site.

provide documentation for the nonroad mobile and onroad mobile data categories, respectively. Fires (wild and prescribed burning) are described in Section 7, and biogenic emissions are described in Section 8.

1.3 Where can I obtain the 2014 NEI data?

The 2014 NEI data are available in several different ways listed below. Data are available to the reporting agencies and EPA staff via the Emission Inventory System (EIS).

1.3.1 Emission Inventory System Gateway

The EIS Gateway is available to all EPA staff, EIS data submitters (i.e., the S/L/T air agency staff), Regional Planning Organization staff that support state, local and tribal agencies, and contractors working for the EPA on emissions related work. The EIS reports functions can be used to obtain raw input datasets and create summary files from these datasets as well as the 2014 NEI and older versions of the NEI such as 2011 and 2008. The 2014 NEI in the EIS is called "2014 NEI FINAL V2." Note that if you run facility-, unit- or process-level reports in the EIS, you will get the 2014 NEI emissions, but the facility inventory, which is dynamic in the EIS, will reflect more current information. For example, if an Agency ID has been changed since the time we ran the reports for the public website (January 2017), then that new Agency ID will be in the Facility Inventory or a Facility Configuration report in the EIS but not in the report on the public website nor the Facility Emissions Summary reports run on the "2014 NEI FINAL V2" in the EIS. Use the link provided above for more information about how to obtain an account and to access the gateway itself.

1.3.2 NEI main webpage

Next, data from the EIS are exported for public release on the NEI main webpage. There are two pages related to the 2014 NEI on the NEI main page website: "2014 NEI Data" and "2014 NEI Documentation." The 2014 NEI Data page includes the most recent **publicly**-available version of the 2014 NEI; this is 2014v2 as of February 2018. The 2014 NEI Documentation page includes the 2014 NEI plan and schedules, all publicly-available supporting materials by inventory data category (e.g., point, nonpoint, onroad mobile, nonroad mobile, events), this TSD, as well as the 2014v1 NEI TSD.

The 2014 NEI Data page includes a query tool that allows for summaries by EIS Sector (see Section 2.4) or the more traditional Tier 1 summary level (CAPs only) used in the EPA Trends Report. Summaries from the 2014 NEI Data site include national-, state-, and county-level emissions for CAPs, HAPs and GHGs. You can choose which states, EIS Sectors, Tiers, and pollutants to include in custom-generated reports to download Comma Separated Value (CSV) files to import into Microsoft® Excel®, Access®, or other spreadsheet or database tools. Biogenic emissions and tribal data (but not tribal onroad emissions) are also available from this tool. Tribal summaries are also posted under the "Additional Summary Data" section of this page.

The source classification codes (SCC) data files section of the webpage provides detailed data files for point, nonpoint, onroad and nonroad data categories via a pull-down menu. These detailed CSV files (provided in zip files) contain emissions at the process level. Due to their size, all but the nonpoint data are broken out into EPA regions. Facility-level by pollutant and events by pollutant summaries are also available. These CSV files must be "linked" (as opposed to imported) to open them with Microsoft® Access®.

The 2014 NEI Documentation page includes links to the NEI TSD and supporting materials referenced in this TSD. This page is a working page, meaning that content is updated as new products are developed.

1.3.3 Air Emissions and "Where you live"

NOTE: Please review table legends which provide the NEI year and version when using the data from these sites.

The Air Emissions website provides emissions of CAPs except for NH_3 using point-and-click maps and bar charts to provide access to summary and detailed emissions data. The maps, charts, and underlying data (in CSV format) can be saved from the website and used in documents or spreadsheets.

In addition, the "Where you live" feature of the Air Emissions website allows users to select states and EIS sectors (see Section 2.1) to create KMZ files used by Google Earth. You must have Google Earth installed on your computer to open the files. You can customize the maps to select the facility types of interest (e.g., airport, steel mill, petroleum refinery, pulp and paper plant), and all other facility types will go into an "Other" category on the maps. The resulting maps allow you to click on the icons for each facility to get a chart of emissions associated with each facility for all criteria pollutants.

1.3.4 Modeling files

The modeling files, provided on the Air Emissions Modeling website, are provided in formats that can be read by the Sparse Matrix Operator Kernel Emissions (SMOKE). These files are also CSV formats that can be read by other systems, such as databases. The modeling files provide the process-level emissions apportioned to release points, and the release parameters for the release points. Release parameters include stack height, stack exit diameter, exit temperature, exit velocity and flow rate. The EPA may make changes to the NEI modeling files prior to use. The 2014 modeling platform is based on the 2014 NEI and is under development; it is expected to be posted in the spring of 2018. Any changes between the NEI and modeling platform data will be described in an accompanying TSD for the 2014 Emissions Modeling Platform, which would also be posted at the above website.

SMOKE flat files by emissions modeling "sector" are available for download on the 2014v2 NEI-based Emissions Modeling FTP siteftp://ftp.epa.gov/EmisInventory/2014/flat_files/. These flat files are the emissions based on the 2014v2 NEI and can be input into SMOKE for processing for air quality modeling. However, for onroad and nonroad mobile sources, we use more finely resolved data for air quality modeling. The data files for nonroad mobile emissions use monthly emissions values. For onroad mobile sources, the emissions are computed hourly based on gridded meteorological data and emission factors. Therefore, these aggregated annual onroad and nonroad modeling files should not be used directly for modeling. Refer to the README file for more details on how to access these SMOKE flat files.

For point and nonpoint sources, the modeling files have the sources split into smaller source groupings (modeling sectors) for emissions modeling because emissions processing methods vary between these source groupings.

1.4 Why is the NEI created?

The NEI is created to provide the EPA, federal, state, local and tribal decision makers, and the national and international public the best and most complete estimates of CAP and HAP emissions. While the EPA is not directly obligated to create the NEI, the Clean Air Act authorizes the EPA Administrator to implement data collection efforts needed to properly administer the NAAQS program. Therefore, the Office of Air Quality Planning and Standards (OAQPS) maintains the NEI program in support of the NAAQS. Furthermore, the Clean Air Act requires states to submit emissions to the EPA as part of their State Implementation Plans (SIPs) that describe how they will attain the NAAQS. The NEI is used as a starting point for many SIP inventory development efforts and for states to obtain emissions from other states needed for their modeled attainment demonstrations.

While the NAAQS program is the basis on which the EPA collects CAP emissions from the S/L/T air agencies, it does not require collection of HAP emissions. For this reason, the HAP reporting requirements are voluntary. Nevertheless, the HAP emissions are an essential part of the NEI program. These emissions estimates allow EPA to assess progress in meeting HAP reduction goals described in the Clean Air Act amendments of 1990. These reductions seek to reduce the negative impacts to people of HAP emissions in the environment, and the NEI allows the EPA to assess how much emissions have been reduced since 1990.

1.5 How is the NEI created?

The NEI is created based on both regulatory and technical components. The Air Emissions Reporting Rule (AERR) is the regulation that requires states to submit CAP emissions, and provides the framework for voluntary submission of HAP emissions. The 2008 NEI was the first inventory compiled using the AERR, rather than its predecessor, the Consolidated Emissions Reporting Rule (CERR). The 2014 NEI is the third AERR-based inventory, and improvements in the 2014 NEI process reflect lessons learned by the S/L/T air agencies and EPA from the prior NEI efforts. The AERR requires agencies to report all sources of emissions, except fires and biogenic sources. Reporting of open fire sources, such as wildfires, is encouraged, but not required. Sources are divided into large groups called “data categories”: stationary sources are “point” or “nonpoint” (county totals) and mobile sources are either onroad (cars and trucks driven on roads) or nonroad (locomotives, aircraft, marine, off-road vehicles and nonroad equipment such as lawn and garden equipment).

The AERR has emissions thresholds above which states must report stationary emissions as “point” sources, with the remainder of the stationary emissions reported as “nonpoint” sources.

The AERR changed the way these reporting thresholds work, as compared to the CERR, by changing these thresholds to “potential to emit” thresholds rather than actual emissions thresholds. In both the CERR and the AERR, the emissions that are reported are actual emissions, despite that the criteria for which sources to report is now based on potential emissions. The AERR requires emissions reporting every year, with additional requirements every third year in the form of lower point source emissions thresholds, and 2014 is one of these third-year inventories.

Table 1-1 provides the potential-to-emit reporting thresholds that applied for the 2014 NEI cycle. “Type B” is the terminology in the rule that represents the lower emissions thresholds required for point sources in the triennial years. The reporting thresholds are sources with potential to emit of 100 tons/year or more for most criteria pollutants, with the exceptions of CO (1000 tons/year), and, updated in the 2014 AERR, Pb (0.5 tons/year, actual). As shown in the table, special requirements apply to nonattainment area (NAA) sources, where even lower thresholds apply. The relevant ozone (O_3), CO, and PM_{10} nonattainment areas that applied during the year that the S/L/T agencies submitted their data for the 2014 NEI are available on the Nonattainment Areas for Criteria Pollutants (Green Book) web site. While not applicable to the 2014 NEI, the AERR thresholds have been further revised to reflect 70 tons/year for PM_{10}, $PM_{2.5}$, and PM precursors for sources within PM_{10} and $PM_{2.5}$ nonattainment areas.

Table 1-1: Point source reporting thresholds (potential to emit) for CAPs in the AERR for the year 2014 NEI

2014 NEI thresholds: potential to emit (tons/yr)			
Pollutant		Everywhere (Type B sources)	NAA sources[1]
1	SO_2	≥ 100	≥ 100
2	VOC	≥ 100	O_3 (moderate) ≥ 100
3	VOC		O_3 (serious) ≥ 50
4	VOC		O_3 (severe) ≥ 25
5	VOC		O_3 (extreme) ≥ 10
6	NO_X	≥ 100	≥ 100
7	CO	≥ 1000	O_3 (all areas) ≥ 100
8	CO		CO (all areas) ≥ 100
9	Pb	≥ 0.5 (actual)	≥ 0.5 (actual)
10	PM_{10}	≥ 100	PM_{10} (moderate) ≥ 100
11	PM_{10}		PM_{10} (serious) ≥ 70
12	$PM_{2.5}$	≥ 100	≥ 100
13	NH_3	≥ 100	≥ 100

[1] NAA = Nonattainment Area. Special point source reporting thresholds apply for certain pollutants by type of nonattainment area. The pollutants by nonattainment area are: Ozone: VOC, NO_X, CO; CO: CO; PM_{10}: PM_{10}

Based on the AERR requirements, S/L/T air agencies submit emissions or model inputs of point, nonpoint, onroad mobile, nonroad mobile, and fires emissions sources. With the exception of California, reporting agencies were required to submit model inputs for onroad and nonroad mobile sources instead of emissions. For the 2014v1 NEI, all these emissions and inputs were required to be submitted to the EPA per the AERR by December 31, 2015 (with an extension given through January 15, 2016). Once the initial reporting NEI period closed, the EPA provided feedback on data quality such as suspected outliers and missing data by comparing to previously established emissions ranges and past inventories. In addition, the EPA augmented the S/L/T data using various sources of data and augmentation procedures. This documentation provides a detailed account of EPA's quality assurance and augmentation methods.

1.5.1 NEI 2014 v2 point source updates

The 2014v1 NEI point source file was produced on July 16, 2016. The 2014v2 was produced November 15, 2017. The process for producing the point source emissions was different from that of the 2014v1 NEI (and previous year inventories) in that we used the 2014v1 as the starting point, and incorporated targeted changes to that dataset rather than re-generating the entire point inventory from the S/L/T and EPA datasets. To do this, the 2014v1 NEI was converted to a dataset, and changes were incorporated into new EPA change datasets (for more detail see the 2014v2 NEI selection hierarchy presented in Section 3.9. In addition, we tagged out 2014v1 NEI data that was found to be incorrect per the S/L/T comments. Facility configuration data such as geographic coordinates and release parameters were updated directly to EIS by S/L/T or by EPA. More information on the 2014v2 updates are provided in Section 3.9.

1.5.2 NEI 2014 v2 nonpoint source updates

There are numerous changes in the nonpoint data category for 2014v2; highlights include, but are not restricted to the following:

- Updated emission factors for agricultural fertilizer application from 2011 to 2014 model outputs
- New EPA estimate for livestock dust that did not exist in 2014v1
- Added VOCs for livestock waste and some animal population updates for several states
- Where available, we updated activity data for many EPA nonpoint tools and EPA estimates
- Re-introduction of precipitation adjustment to unpaved and paved roads greatly reduces PM emissions in 2014v2 for these sources
- Recomputed HAPs for agricultural field burning for most states to satisfy QA checks
- Revised boiler/engine split for distillate industrial and commercial/institutional fuel combustion
- New port shapes redrawn such that emissions are placed only over water and not port land area; also new submittals for the Great Lakes states and Delaware
- New EPA estimates for locomotives, county-level replaces link-based estimates
- New activity data for oil and gas production and exploration, updated basin-specific activity data and emission factors, and some states resubmitted data
- Mercury tools updated from year 2011 to year 2014 activity data; general laboratory activities, missing in 2014v1, are carried forward from the 2011 NEI

Each subsection in the Nonpoint Section (4) discusses in detail how the EPA data changed between 2014v1 and 2014v2. S/L/Ts also resubmitted data based on their own review.

1.5.3 NEI 2014 v2 mobile source updates

Three states provided updates to their nonroad inputs: Delaware, Georgia and North Carolina. There were more substantial updates for the onroad data category:

- New 2014 vehicle populations and fleet characteristics,
- New default vehicle speed distributions and relative hourly and day-type VMT distributions and the local level,
- New county database submittals and minor changes to the representative county groups based on new 2014 age distribution data,
- Age distributions for representative county databases now reflect population-weighted average of the member county age distributions,

1.5.4 NEI 2014 v2 fires updates

Wild land and prescribed fire emissions were altered in two states for the 2014v2 NEI: Georgia and Washington. For Georgia, their 2014v1 VOC HAPs violated our QA check of being less than the VOC estimates. For 2014v2, EPA provided Georgia with appropriate HAP emission factors that were then used for 2014v2. For Washington, they provided their own estimates and documentation for 2014v2 to replace EPA estimates used in 2014v1.

1.6 Who are the target audiences for the 2014 NEI?

The comprehensive nature of the NEI allows for many uses and, therefore, its target audiences include EPA staff and policy makers, the U.S. public, other federal and S/L/T decision makers, and other countries. Table 1-2 below lists the major current uses of the NEI and the plans for use of the 2014 NEI in those efforts. These uses include those by the EPA in support of the NAAQS, Air Toxics, and other programs as well as uses by other federal and regional agencies and for international needs. In addition to this list, the NEI is used to respond to Congressional inquiries, provide data that supports university research, and allow environmental groups to understand sources of air pollution.

Table 1-2: Examples of major current uses of the NEI

Audience	Purposes
U.S. Public	Learn about sources of air emissions
EPA – NAAQS	Regulatory Impact Analysis – benefits estimates using air quality modeling
	NAAQS Implementations, including State Implementation Plans (SIPs)
	Monitoring Rules
	Final NAAQS designations
	NAAQS Policy Assessments
	Integrated Science Assessments
	Transport Rule air quality modeling (e.g., Clean Air Interstate Rule, Cross-State Air Pollution Rule)
EPA – Air toxics	National Air Toxics Assessment (NATA)
	Mercury and Air Toxics Standard – mercury risk assessment and Regulatory Impact Assessment
	National Monitoring Programs Annual Report
	Toxicity Weighted emission trends for the Government Performance and Reporting Act (GPRA)
	Residual Risk and Technology Review – starting point for inventory development
EPA – other	NEI Reports – analysis of emissions inventory data
	Report on the Environment
	Air Emissions website for providing graphical access to CAP emissions for state maps and Google Earth views of facility total emissions
	Department of Transportation, national transportation sector summaries of CAPs
	Black Carbon Report to Congress
Other federal or regional agencies	Modeling in support of Regional Haze SIPs and other air quality issues
International	United Nations Environment Programme (UNEP) – global and North American Assessments
	The Organization for Economic Co-operation and Development (OECD) - environmental data and indicators report
	UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP) - emission reporting requirements, air quality modeling, and science assessments
	Community Emissions Data System (CEDS) - science network for earth system, climate, and atmospheric modeling
	Commission for Environmental Cooperation (CEC) - North American emissions inventory improvement and reduction policies
	U.S. and Canada Air Quality Reports
	Arctic Contaminants Action Program (ACAP) - national environmental and emission reduction strategy for the Arctic Region
Other outside parties	Researchers and graduate students

1.7 What are appropriate uses of the 2014 NEI and what are the caveats about the data?

As shown in the preceding section, the NEI provides a readily-available comprehensive inventory of both CAP and HAP emissions to meet a variety of user needs. Although the accuracy of individual emissions estimates will vary from facility-to-facility or county-to-county, the NEI largely meets the needs of these users in the aggregate. Some NEI users may wish to evaluate and revise the emission estimates for specific pollutants from specific source types for either the entire U.S. or for smaller geographical areas to meet their needs. Regulatory uses of the NEI by the EPA, such as for interstate transport, always include a public review and comment period. Large-scale assessment uses, such as the NATA study, also provide review periods and can serve as an effective screening tool for identifying potential risks.

One of the primary goals of the NEI is to provide the best assessment of current emissions levels using the data, tools and methods currently available. For significant emissions sectors of key pollutants, the available data, tools and methods typically evolve over time in response to identified deficiencies and the need to understand the costs and benefits of proposed emissions reductions. As these method improvements have been made, there have not been consistent efforts to revise previous NEI year estimates to use the same methods as the current year. Therefore, care must be taken when reviewing different NEI year publications as a time series with the goal of determining the trend or difference in emissions from year to year. An example of such a method change in the 2008 NEI v3 and 2011 NEI is the use of the Motor Vehicle Emissions Simulator (MOVES) model for the onroad data category. Previous NEI years had used the Mobile Source Emission Factor Model, version 6 (MOBILE6) and earlier versions of the MOBILE model for this data category. The 2011 NEI (2011v2) also used an older version of MOVES (2014) that has been updated in the current 2014 NEI (MOVES2014a). The new version of MOVES (used in both 2014v1 and 2014v2) also calculates nonroad equipment emissions, adding VOCs and toxics, updating the gasoline fuels used for nonroad equipment to be consistent with those used for onroad vehicles. These changes in MOVES lead to a small increase in nonroad NO_X emissions in some locations, introducing additional uncertainty when comparing 2014 NEI to past inventories.

Other significant emissions sectors have also had improvements and, therefore, trends are also impacted by inconsistent methods. Examples include paved and unpaved road PM emissions, ammonia fertilizer and animal waste emissions, oil and gas production, residential wood combustion, solvents, industrial and commercial/institutional fuel combustion and commercial marine vessel emissions.

Users should take caution in using the emissions data for filterable and condensable components of particulate matter (PM10-FIL, PM2.5-FIL and PM-CON), which is not complete and should not be used at any aggregated level. These data are provided for users who wish to better understand the components of the primary PM species, where they are available, in the disaggregated, process-specific emissions reports. Where not reported by S/L/T agencies, the EPA augments these components (see Section 2.2.4). However, not all sources are covered by this routine, and in mobile source and fire models, only the primary particulate species are estimated. Thus, users interested in PM emissions should use the primary species of particulate matter (PM10-PRI and PM25-PRI), described in this document simply as PM_{10} and $PM_{2.5}$.

1.8 Known issues in the 2014v2 NEI

Not every identified issue in the 2014v1 NEI was resolved for the 2014v2 NEI. Below is a list of issues in the 2014v2 NEI that we intend to resolve in the 2017 NEI:

- Reconcile EPA tool emission factors and EIS HAP augmentation profiles, ensure VOC HAP vs VOC QA check is possible
- Improved emission factors for key source categories, to be determined
- General mistakes in execution:
    - We “over-tagged” EPA nonpoint estimates for several states and source categories. These tags were intended to apply to only 1 pollutant but were erronesouly applied to all pollutants.

However, these missing EPA estimates are very small for CAPs and most HAPs except for the following states and sectors:

    - Idaho: Cumulative 6,110 tons of CO, 45 tons of NH3, 80 tons of NOX, 855 tons of PM2.5 and PM10, 13 tons of SO2 and 1,250 tons of VOC from residential wood combustion sources freestanding and insert non-certified and certified-catalytic wood stoves (SCCs 2104008210, 2104008230, 2104008310, and 2104008330).
    - Wyoming: 13 tons of NOX from gas well dehydrators (SCC 2310021400) and 7 tons of NOX, 39 tons of CO, and 84 tons of SO2 from “Oil Well Tanks - Flashing & Standing/Working/Breathing” (SCC 2310010200).
  - We did not remove a double-count in New Jersey ICI distillate fuel combustion (approximately 1,000 tons of NOX)
  - Missing HAPs for an agricultural burning SCC
  - Minnesota alerted EPA that several nonpoint sources had minor issues. EPA estiamtes for residential wood combustion emissions for certified catalytic freestanding and insert wood stoves were erroneously gap-filled where MN-submitted data did not exist; this resulted in approximately 131 tons of PM2.5 emissions from EPA that should not have been included. Similar undesired EPA gap-filling of solvent degreasing (1,319 tons of VOC) and mercury from human cremation (13 pounds of mercury) were identified.
- Improved point subtraction when computing nonpoint fuel industrial and commercial/institutional combustion
- Improved characterization of unpaved roads
- Improved coverage of survey data for residential wood combustion
- New emissions source for agricultural silage (VOC)

2 2014 NEI contents overview

2.1 What are EIS sectors and what list was used for this document?

First used for the 2008 NEI, EIS Sectors continue to be used for the 2014 NEI. The sectors were developed to better group emissions for both CAP and HAP summary purposes. The sectors are based simply on grouping the emissions by the emissions process based on the SCC to the EIS sector. In building this list, we gave consideration not only to the types of emissions sources our data users most frequently ask for, but also to the need to have a relatively concise list in which all sectors have a significant amount of emissions of at least one pollutant. The SCC-EIS Sector cross-walk used for the summaries provided in this document is available in the comma-separated values (CSV) file "source_classification_codes (9).csv" that can be imported into a Microsoft® Excel ® spreadsheet. No changes were made to the SCC-mapping or sectors used for the 2014 NEI except where SCCs were retired or new SCCs were added. Users of the NEI are free to obtain the SCC-level data. SCCs and their associated sectors are available from the SCC Search Page.

Some of the sectors include the nomenclature "NEC," which stands for "not elsewhere classified." This simply means that those emissions processes were not appropriate to include in another EIS sector and their emissions were too small individually to include as its own EIS sector.

Since the 2008 NEI, the inventory has been compiled using five major categories that are also data categories in the EIS: point, nonpoint, onroad, nonroad and events. The event category is used to compile day-specific data from prescribed burning and wildfires. While events could be other intermittent releases such as chemical spills and structure fires, prescribed burning and wildfires have been a focus of the NEI creation effort and are the only emission sources contained in the event data category.

Table 2-1 shows the EIS sectors or source category component of the EIS sector in the left most column. EIS data categories -Point, Nonpoint, Onroad, Nonroad, and Events- that have emissions in these sectors/source categories are also reflected. This table also identifies in the rightmost column the section number of this document that provides more information about that EIS sector or source category **if the EPA was involved in creating emissions for that component of the NEI**. Many Industrial Processes-related EIS sectors do not have detailed sector-specific documentation because the emissions are comprised almost exclusively from S/L/T point and/or nonpoint submittals. As discussed in the next section, the EPA had little, if any, input to these sectors other than augmenting HAPs or tagging out unexpected data.

As Table 2-1 illustrates, many EIS sectors include emissions from more than one EIS data category because the EIS sectors are compiled based on the type of emissions sources rather than the data category. Note that the EIS sector "Mobile – Aircraft" is part of the point and nonpoint data categories and "Mobile – Commercial Marine Vessels" and "Mobile – Locomotives" is part of the nonpoint data category. We include biogenics emissions, "Biogenics - Vegetation and Soil," in the nonpoint data category in the EIS; however, we document biogenics in its own Section (8). NEI users who aggregate emissions by EIS data category rather than EIS sector should be aware that these changes will give differences from historical summaries of "nonpoint" and "nonroad" data unless care is taken to assign those emissions to the historical grouping.

Table 2-1: EIS sectors/source categories with EIS data category emissions reflected, and where provided, document sections

Component EIS Sector or EIS Sector: Source Category Name	Point	Nonpoint	Onroad	Nonroad	Event	Document Section(s)
Agriculture - Crops & Livestock Dust		☑				4.3
Agriculture - Fertilizer Application		☑				4.4
Agriculture - Livestock Waste	☑	☑				4.5
Biogenics - Vegetation and Soil		☑				8
Bulk Gasoline Terminals	☑	☑				4.6
Commercial Cooking		☑				4.7
Dust - Construction Dust	☑	☑				4.8
Dust - Paved Road Dust		☑				4.9
Dust - Unpaved Road Dust		☑				4.10
Fires - Agricultural Field Burning		☑				4.11
Fires - Prescribed Burning					☑	7
Fires - Wildfires					☑	7
Fuel Comb - Comm/Institutional - Biomass	☑	☑				4.12
Fuel Comb - Comm/Institutional - Coal	☑	☑				4.12
Fuel Comb - Comm/Institutional - Natural Gas	☑	☑				4.12
Fuel Comb - Comm/Institutional - Oil	☑	☑				4.12
Fuel Comb - Comm/Institutional - Other	☑	☑				4.12
Fuel Comb - Electric Generation - Biomass	☑					3.4
Fuel Comb - Electric Generation - Coal	☑					3.4
Fuel Comb - Electric Generation - Natural Gas	☑					3.4
Fuel Comb - Electric Generation - Oil	☑					3.4
Fuel Comb - Electric Generation - Other	☑					3.4
Fuel Comb - Industrial Boilers, ICEs - Biomass	☑	☑				4.12
Fuel Comb - Industrial Boilers, ICEs - Coal	☑	☑				4.12
Fuel Comb - Industrial Boilers, ICEs - Natural Gas	☑	☑				4.12
Fuel Comb - Industrial Boilers, ICEs - Oil	☑	☑				4.12
Fuel Comb - Industrial Boilers, ICEs - Other	☑	☑				4.12
Fuel Comb - Residential - Natural Gas		☑				4.13
Fuel Comb - Residential - Oil		☑				4.13
Fuel Comb - Residential - Other		☑				4.13
Fuel Comb - Residential - Wood		☑				4.14
Gas Stations	☑	☑				4.6
Industrial Processes - Cement Manufacturing	☑					
Industrial Processes - Chemical Manufacturing	☑	☑				
Industrial Processes - Ferrous Metals	☑					
Industrial Processes - Mining	☑	☑				4.15
Industrial Processes - NEC	☑	☑				

Component EIS Sector or EIS Sector: Source Category Name	Point	Nonpoint	Onroad	Nonroad	Event	Document Section(s)
Industrial Processes - Non-ferrous Metals	☑	☑				
Industrial Processes - Oil & Gas Production	☑	☑				4.16
Industrial Processes - Petroleum Refineries	☑	☑				
Industrial Processes - Pulp & Paper	☑					
Industrial Processes - Storage and Transfer	☑	☑				4.6
Miscellaneous Non-Industrial NEC: Residential Charcoal Grilling		☑				4.17
Miscellaneous Non-Industrial NEC: Portable Gas Cans		☑				4.18
Miscellaneous Non-Industrial NEC: Nonpoint Hg		☑				4.2
Miscellaneous Non-Industrial NEC (All other)	☑	☑				
Mobile – Aircraft	☑					3.2
Mobile - Commercial Marine Vessels		☑				4.19
Mobile – Locomotives	☑	☑				3.3 & 4.20
Mobile - NonRoad Equipment – Diesel	☑			☑		5
Mobile - NonRoad Equipment – Gasoline	☑			☑		5
Mobile - NonRoad Equipment – Other	☑			☑		5
Mobile - Onroad – Diesel Heavy Duty Vehicles			☑			6
Mobile - Onroad – Diesel Light Duty Vehicles			☑			6
Mobile - Onroad – Gasoline Heavy Duty Vehicles			☑			6
Mobile - Onroad – Gasoline Light Duty Vehicles			☑			6
Solvent - Consumer & Commercial Solvent Use: Agricultural Pesticides		☑				4.21
Solvent - Consumer & Commercial Solvent Use: Asphalt Paving		☑				4.22
Solvent - Consumer & Commercial Solvent Use: All Other Solvents		☑				4.23
Solvent - Degreasing	☑	☑				4.23
Solvent - Dry Cleaning	☑	☑				4.23
Solvent - Graphic Arts	☑	☑				4.23
Solvent - Industrial Surface Coating & Solvent Use	☑	☑				4.23
Solvent - Non-Industrial Surface Coating		☑				4.23
Waste Disposal: Open Burning		☑				4.24
Waste Disposal: Nonpoint POTWs		☑				4.25
Waste Disposal: Human Cremation		☑				4.26
Waste Disposal: Nonpoint Hg		☑				4.2
Waste Disposal (all remaining sources)	☑	☑				

2.2 How is the NEI constructed?

Data in the NEI come from a variety of sources. The emissions are predominantly from S/L/T agencies for both CAP and HAP emissions. In addition, the EPA quality assures and augments the data provided by states to assist with data completeness, particularly with the HAP emissions since the S/L/T HAP reporting is voluntary.

The NEI is built by data category for point, nonpoint, nonroad mobile, onroad mobile and events. Each data category has a self-contained inventory where multiple datasets are blended to create the final NEI "selection." Each data category selection includes S/L/T data and numerous other datasets that are discussed in more detail in each of the following sections in this document. In general, S/L/T data take precedence in the selection hierarchy, which means that it supersedes any other data that may exist for a specific county/tribe/facility/pollutant/process. In other words, the selection hierarchy is built such that the preferred source of data, usually S/L/T, is chosen when multiple sources of data are available. There are exceptions, to this general rule, which arise based on quality assurance checks and feedback from S/L/Ts that we will discuss in later sections. These exceptions are implemented by NEI developers using "tags" within EIS.

The EPA uses augmentation and additional EPA datasets to create the most complete inventory for stakeholders, for use in such applications as NATA, air quality modeling, national rule assessments, international reporting, and other reports and public inquiries. Augmentation to S/L/T data, in addition to EPA datasets, fill in gaps for sources and/or pollutants often not reported by S/L/T agencies. The basic types of augmentation are discussed in the following sections.

2.2.1 Toxics Release Inventory data

The EPA used air emissions data from the 2014 Toxics Release Inventory (TRI) to supplement point source HAP and NH_3 emissions provided to EPA by S/L/T agencies. For 2014, all TRI emissions values that could reasonably be matched to an EIS facility were loaded into the EIS for viewing and comparison if desired, but only those pollutants that were not reported anywhere at the EIS facility by the S/L/T agency were considered for inclusion in the 2014 NEI.

The TRI is an EPA database containing data on disposal or other releases including air emissions of over 650 toxic chemicals from approximately 21,000 facilities. One of TRI's primary purposes is to inform communities about toxic chemical releases to the environment. Data are submitted annually by U.S. facilities that meet TRI reporting criteria. Section 3 provides more information on how TRI data was used to supplement the point inventory.

2.2.2 Chromium speciation

The 2014 reporting cycle included 5 valid pollutant codes for chromium, as shown in Table 2-2.

Table 2-2: Valid chromium pollutant codes

Pollutant Code	Description	Pollutant Category Name	Speciated?
1333820	Chromium Trioxide	Chromium Compounds	yes
16065831	Chromium III	Chromium Compounds	yes
18540299	Chromium (VI)	Chromium Compounds	yes
7440473	Chromium	Chromium Compounds	no
7738945	Chromic Acid (VI)	Chromium Compounds	yes

In the above table, all pollutants but "chromium" are considered speciated, and so for clarity, chromium (pollutant 7440473) is referred to as "total chromium" in the remainder of this section. Total chromium could contain a mixture of chromium with different valence states. Since one key inventory use is for risk assessment, and since the valence states of chromium have very different risks, speciated chromium pollutants are the most useful pollutants for the NEI. Therefore, the EPA speciates S/L/T-reported and TRI-based total chromium into hexavalent chromium and non-hexavalent chromium. Hexavalent chromium, or Chromium (VI), is considered high risk and other valence states are not. Most of the non-hexavalent chromium is trivalent chromium

(Chromium III); therefore, the EPA characterized all non-hexavalent chromium as trivalent chromium. The 2014 NEI does not contain any total chromium, only the speciated pollutants shown in Table 2-2.

This section describes the procedure we used for speciating chromium emissions from total chromium that was reported by S/L/T agencies.

We used the EIS augmentation feature to speciate S/L/T agency reported total chromium. For point sources, the EIS uses the following priority order for applying the factors:

1) By Process ID
2) By Facility ID
3) By County
4) By State
5) By Emissions Type (for NP only)
6) By SCC
7) By Regulatory Code
8) By NAICS
9) A Default value if none of the others apply

For the 2014 chromium augmentation, only the “By Facility ID” (2), “By SCC” (6), and “By Default” (9) were used. The EIS generates and stores an EPA dataset containing the resultant hexavalent and trivalent chromium species.

For all other data categories (e.g., nonpoint, onroad and nonroad), chromium speciation is performed at the SCC level.

This procedure generated hexavalent chromium (Chromium (VI)) and trivalent chromium (Chromium III), and it had no impact on S/L/T agency data that were provided as one of the speciated forms of chromium. The sum of the EPA-computed species (hexavalent and trivalent chromium) equals the mass of the total chromium (i.e., pollutant 7440473) submitted by the S/L/T agencies.

The EPA then used this dataset in the 2014 NEI selection by adding it to the data category-specific selection hierarchy and by excluding the S/L/T agency unspeciated chromium from the selection through a pollutant exception to the hierarchy. It was not necessary to speciate chromium from any of the EPA datasets, because the EPA data contains only speciated chromium.

Most of the speciation factors used in the 2014 NEI are SCC-based and are the same as were used in 2011, based on data that have long been used by the EPA for NATA and other risk projects. However, some of the values were updated based on data used or developed by OAQPS during rule development and for the 2011 NATA review. The speciation factors are accessed in the EIS through the reference data link “Augmentation Priority Order.” The “Priority Data” table provides the factors used for point sources, and the “Priority Data Area” provides the factors used for data in the nonpoint/onroad/nonroad categories. For access by non-EIS users, the factors are included in the zip file ChromiumAugFactors.zip. If a particular emission source of total chromium is not covered by the speciation factors specified by any of these attributes, a default value of 34 percent hexavalent chromium, 66 percent trivalent chromium is applied.

2.2.3 HAP augmentation

The EPA supplements missing HAPs in S/L/T agency-reported data. HAP emissions are calculated by multiplying appropriate surrogate CAP emissions by an emissions ratio of HAP to CAP emission factors. For the 2014 NEI, we augmented HAPs for the point and nonpoint data categories. Generally, for point sources, the CAP-to-HAP ratios were computed using uncontrolled emission factors from the WebFIRE database (which contains primarily AP-42 emissions factors). For nonpoint sources, the ratios were computed from the EPA-generated nonpoint data, which contain both CAPs and HAPs where applicable.

HAP augmentation is performed on each emissions source (i.e., specific facility and process for point sources, county and process level for nonpoint sources) using the same EIS augmentation feature as described in chromium speciation. However, unlike chromium speciation, there is no default augmentation factor so that not every process that has S/L/T CAP data will end up with augmented HAP data.

HAP augmentation input pollutants are S/L/T-submitted VOC, PM10-PRI, PM25-PRI, SO2, and PM10-FIL. The resulting output can be a single output pollutant or a full suite of output pollutants. Not every source that has a CAP undergoes HAP augmentation (i.e., livestock NH_3, fugitive dust PM25-PRI). The sum of the HAP augmentation factors does not need to equal 1 (100%); however, we try to ensure, for example, that the sum of HAP-VOC factors is less than 1 for mass balance. HAP augmentation factors are grouped into profiles that contain unique output pollutant factors related to a type of source. Assigning these profiles to the individual sources depends on the source attributes, commonly the SCC.

There are business rules specific to each data category discussed in the point (Section 3) and nonpoint (Section 4). The ultimate goal is to prevent double-counting of HAP emissions between S/L/T data and the EPA HAP augmentation output, and to prevent, where possible, adding HAP emissions to S/L/T-submitted processes that are not desired. NEI developers use their judgment on how to apply HAP augmentation to the resulting NEI selection.

Caveats

HAP augmentation does have limitations; HAP and CAP emission factors from WebFIRE do not necessarily use the same test methods. In some situations, the VOC emission factor is less than the sum of the VOC HAP emission factors. In those situations, we normalize the HAP ratios so as not to create more VOC HAPs than VOC. We are also aware that there are many similar SCCs that do not always share the same set of emission factors/output pollutants. We do not apply ratios based on emission factors from similar SCCs other than for mercury from combustion SCCs. We would prefer to get HAPs reported from reporting agencies or get the data from other sources (compliance data from rule), but such data are not always available.

Because much of the AP-42 factors are 20+ years old, many incremental edits to these factors have been made over time. We have removed some factors based on results of the 2011 NATA review. For example, we discovered ethylene dichloride was being augmented for SCCs related to gasoline distribution. This pollutant was associated with leaded gasoline which is no longer used. Therefore, we removed it from our HAP augmentation between 2011 NEI v2 and 2014. We also received specific facility and process augmentation factors, which we incorporated into for the augmentation for 2014 NEI.

HAP augmentation can sometimes create HAP emissions that exceed the largest S/L/T-reported value nationally for a given pollutant and SCC. These high values are screened out via tags (see Section 2.2.6) and are not in the 2014 NEI. These tagged values are available for S/L/T air agency review. While they could be valid, they could also indicate a CAP emissions overestimate or incorrect SCC assignment for a source.

For point sources, HAPs augmentation data are not used when S/L/T air agency data exists at any process at the facility for the same pollutant. That means that if a S/L/T reports a particular HAP at some processes but misses others, then those other processes will not be augmented with that HAP. A more thorough review of that situation was done for mercury for 2014v2, which led to some additional augmented Hg being used.

2.2.4 PM augmentation

Particulate matter (PM) emissions species in the NEI are: primary PM_{10} (called PM10-PRI in the EIS and NEI) and primary $PM_{2.5}$ (PM25-PRI), filterable PM_{10} and filterable $PM_{2.5}$ (PM10-FIL and PM25-FIL) and condensable PM (PM-CON). The EPA needed to augment the S/L/T agency PM components for the point and nonpoint inventories to ensure completeness of the PM components in the final NEI and to ensure that S/L/T agency data did not contain inconsistencies. An example of an inconsistency is if the S/L/T agency submitted a primary $PM_{2.5}$ value that was greater than a primary PM_{10} value for the same process. Commonly, the augmentation added condensable PM or PM filterable (PM10-FIL and/or PM25-FIL) where none was provided, or primary $PM_{2.5}$ where only primary PM_{10} was provided.

In general, emissions for PM species missing from S/L/T agency inventories were calculated by applying factors to the PM emissions data supplied by the S/L/T agencies. These conversion factors were first used in the 1999 NEI's "PM Calculator" as described in an NEI conference paper [ref 1]. The resulting methodology allows the EPA to derive missing PM10-FIL or PM25-FIL emissions from incomplete S/L/T agency submissions based on the SCC and PM controls that describe the emissions process. In cases where condensable emissions are not reported, conversion factors are applied to S/L/T agency reported PM species or species derived from the PM Calculator databases. The PM Calculator, has undergone several edits since 1999; now called the "PM Augmentation Tool," this Microsoft ® Access ® database is available on the NEI PM Augmentation site.

The PM Augmentation Tool is used only for point and nonpoint sources, and the output from the tool is heavily-screened prior to use in the NEI. This screening is done to prevent trivial overwriting of S/L/T data from PM Augmentation Tool calculations, particularly for primary PM submittals by S/L/Ts. More details on the caveats to using the PM Augmentation Tool are discussed in Section 3 on point sources and Section 4 on nonpoint sources.

2.2.5 Other EPA datasets

In addition to TRI, chromium speciation, HAP and PM augmentation, the EPA generates other data to produce a complete inventory. A new EPA dataset in the 2014 NEI "2014EPA_PMspecies", provides speciated PM2.5 and "DIESEL" PM emissions for the point, nonpoint, onroad mobile, and nonroad mobile data categories. This dataset is a result of offline emissions speciation where the NEI PM25-PRI emissions are split into the five $PM_{2.5}$ species: elemental (also referred to as "black") carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). Also adds a copy of PM2.5-PRI and PM10-PRI from diesel engines, relabeled as DIESEL-PM25 and DIESEL-PM10, respectively, are added pollutants in this dataset.

Examples of EPA data for point sources, discussed in Section 3, include EPA landfills, electric generating units (EGUs), airports, railyards, and offshore oil and gas platforms.

For nonpoint sources, discussed in Section 4, other EPA data are the defaults that are provided in the EPA nonpoint tools that S/L/Ts agency staff can generate emission estimates. Examples of these nonpoint tools include residential wood combustion, industrial and commercial/institutional fuel combustion, solvent utilization, fugitive dust, oil and gas exploration and production and agricultural pesticide application. The EPA also generates emission estimates as stand-alone datasets that do not have editable inputs; examples of these datasets include biogenics, agricultural livestock and fertilizer application.

We develop and document EPA-generated nonroad mobile-type sources that are in the nonpoint inventory separate from the nonroad equipment sources. These nonpoint, but nonroad mobile-type, sources include rail emissions except railyards and commercial marine vessel ports and in-transit (underway) sources.

We only incorporate data from these other EPA datasets for sources and pollutants that are not provided by S/L/T data. We perform analysis to prevent double-counting of S/L/T agency and EPA data, including using the information included in a nonpoint survey that S/L/T air agencies provided. The information provided by the survey indicates whether nonpoint source categories are covered in partly or wholly in point submittals, represented by another reported process (SCC) type, or are not present in their state or local jurisdiction.

2.2.6 Data Tagging

S/L/T agency data generally is used first when creating the NEI selection. When S/L/T data are used, then the NEI would not use other data (primarily EPA data from stand-alone datasets or HAP, PM or TRI augmentation) that also may exist for the same process/pollutant. Thus, in most cases the S/L/T agency data are used; however, for several reasons, sometimes we need to exclude, or "tag out" S/L/T agency data. Examples of these "S/L/T tags" are when S/L/T agency staff alert the EPA to exclude their data (because of a mistake or outdated value), or when EPA staff find problems with submitted data. An example of the latter scenario is when a S/L/T agency reported only one HAP where several others would be expected, or a S/L/T agency has resubmitted older inventory data. The EPA sector leads contact S/L/T data submitters in cases where the EPA tags out S/L/T data and gives the S/L/T agencies an opportunity to correct problems themselves.

In addition to S/L/T tags, a more common tag is to block EPA-generated data from being used, which would otherwise backfill in "gaps" in S/L/T agency data. For example, S/L/T agencies may inventory all Stage 1 gasoline distribution in their point inventory submittal and have none remaining for the nonpoint inventory; EPA nonpoint Stage 1 gasoline distribution estimates therefore need to be tagged out to prevent EPA nonpoint data from backfilling a complete (point) S/L/T inventory. The EPA tags are far more common and automated for the nonpoint data category where a new nonpoint survey was created for the 2014 NEI. The nonpoint survey is described in more detail in Section 4.

2.2.7 Inventory Selection

Once all S/L/T and EPA data are quality assured in the EIS, and all augmentation and data tagging are complete, then we use the EIS to create a data category-specific inventory selection. To do this, each EIS dataset is assigned a priority ranking prior to running the selection with EIS. The EIS then performs the selection at the most detailed inventory resolution level for each data category. For point sources, this is the process and pollutant level (which includes facility and unit). For nonpoint sources, it is the process (SCC)/shape ID (i.e., rail lines, ports and shipping lanes) and pollutant level. For onroad and nonroad sources, it is process/pollutant, and for events it is day/location/process and pollutant. At these resolutions, the inventory selection process uses data based on highest priority and excludes data where it has been tagged. The EPA then quality assures this final blended inventory to ensure expected processes/pollutants are included or excluded. The EIS uses the inventory selection to also create the SMOKE Flat Files, EIS reports and data that appear on the NEI website.

2.3 What are the sources of data in the 2014 NEI?

This section shows the contributions of S/L/T agency data to total emissions for each major data category. Figure 2-1 shows the proportion of CAP, select HAPs, and HAP group emissions from various data sources in the NEI for nonpoint data category sources. Biogenic sources, all EPA data, are not included in this table. Acid Gases include the following pollutants: hydrogen cyanide, hydrochloric acid, hydrogen fluoride, and chlorine. HAP VOC emissions consist of dozens of VOC HAP species, that in-aggregate, should be less than VOC in our QA checks. HAP metal emissions consist of the following compound groups: Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Manganese, Mercury, Nickel and Selenium. More than 50% of nonpoint pollutant totals come from some type of EPA source, except for SO_2 and VOC which are slightly more-covered by S/L/T submittals. The large “EPA Other” bar for PM_{10} is predominantly dust sources from unpaved roads, agricultural dust from crop cultivation, and construction dust.

Figure 2-1: Relative contributions for various data sources of Nonpoint emissions for CAPs and select HAPs

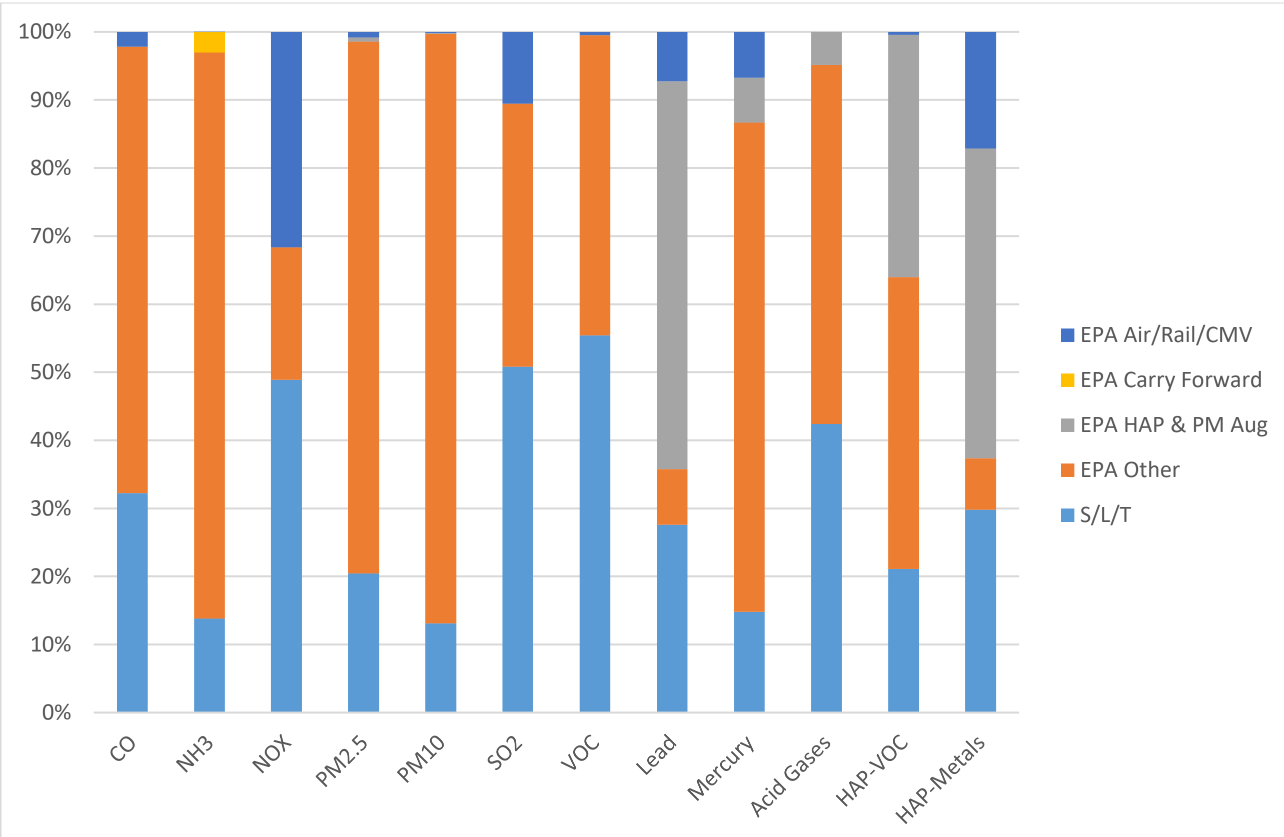
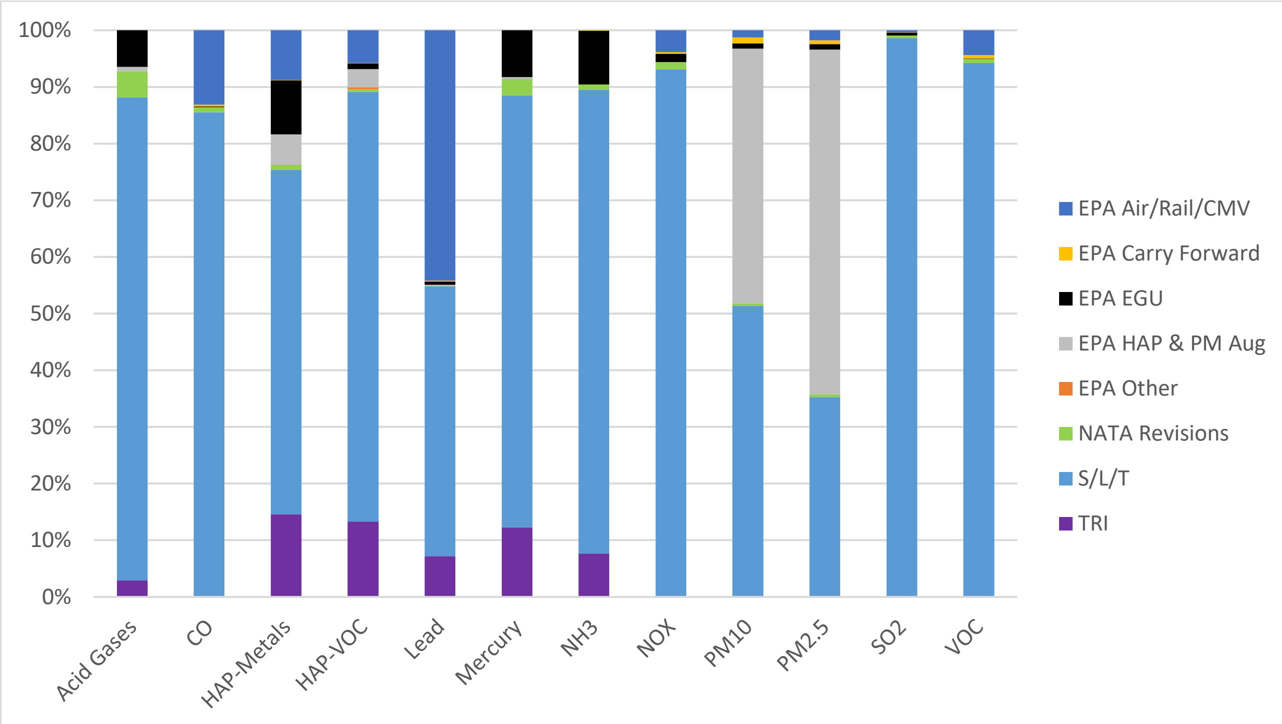


Figure 2-2 shows the proportion of CAP, select HAPs, and HAP group emissions from various data sources in the NEI for point data category sources. Except for PM, most point emissions come from S/L/T-submitted data. PM augmentation (see Section 2.2.3) accounts for a significant portion of PM point emissions. The data sources shown in the figure are described in more detail in Section 3.

Figure 2-2: Relative contributions for various data sources of Point emissions for CAPs and select HAPs



We did not compute relative contributions of emissions from nonroad and onroad data categories because of the nature in how emissions are created for these sources -via a mix of S/L/T and EPA activity data and processed through the MOVES2014 model. California, which uses its own onroad and nonroad mobile models, was the only state that provided emissions rather than inputs for EPA models (this is in accordance with the AERR). All other states were required to provide inputs to the EPA models. Onroad and nonroad mobile data categories use the MOVES emissions model, and the EPA primarily collected model inputs from S/L agencies for these categories and ran the models using these inputs to generate the emissions. The S/L agencies that provided inputs are presented in the nonroad and onroad portions of the document, Section 5 and Section 6, respectively.

The tables below provide more detail about which S/L/T agencies submitted data to the NEI for the point and nonpoint data categories. In Sections 3 through 6, we explain more about what data were used by the EPA to create the NEI for each sector. Usually, the EPA uses the data provided by the S/L/T agencies as described above in Section 2.2.6. Table 2-3 presents the percentages of total agency-wide point source emissions mass provided by that air agency. A value of 100 percent reflects a pollutant where all emissions were submitted by the S/L/T agency and no other data or augmentation was used. Conversely, missing entries reflect that the reporting agency provided no emissions for that pollutant; a value of zero indicates very small, but not-zero, emissions submitted by the reporting agency.

Table 2-4 provides a similar table, but for the entire nonpoint data category, excluding biogenic emissions. We did not create similar tables for nonroad and onroad mobile data categories because input data, not emissions are collected from S/L/T reporting agencies (except for California, where all emissions come from the state). Sections 5 and 6 describe which reporting agencies submitted MOVES inputs for these sectors. Similar tables are provided at a more refined level in Section 4 for various nonpoint data category sector groups such as Residential Wood Combustion, Oil and Gas Production, Industrial and Commercial/Institutional Fuel Combustion and Gasoline Distribution.

Table 2-3: Point inventory percentage submitted by reporting agency to total emissions mass

Agency	CO	NH3	NOX	PM10	PM2.5	SO2	VOC	Lead	HAP VOC	HAP Metals	Acid Gases
Alabama Department of Environmental Management	87	90	95			100	93	48	90	64	98
Alaska Department of Environmental Conservation	52	99	94	89	25	92	62	78		74	
Arizona Department of Environmental Quality	67	84	90	77	59	97	56	63	37	75	58
Arkansas Department of Environmental Quality	84	80	98	98	8	100	98	40	91	81	99
Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	0		97	4	1	56	96		11	1	
California Air Resources Board	52	97	72	86	85	84	91	11	50	29	51
Chattanooga Air Pollution Control Bureau (CHCAPCB)	73	93	94	98	42	73	96	51	94	27	100
City of Albuquerque	58	1	74	54	35	79	75	1	54	1	29
Clark County Department of Air Quality and Environmental Management	85	85	73	94	76	91	52		11	90	18
Coeur d'Alene Tribe	100		100	81	56	100	100	8		0	
Colorado Department of Public Health and Environment	80		95	98	95	99	97	20	86	58	95
Confederated Tribes of the Colville Reservation, Washington	100		100	66	84	100	100				
Connecticut Department of Energy and Environmental Protection	47	94	93	92	91	97	85	6	43	43	99
DC-District Department of the Environment	98		97	97	97	100	97	86		39	
Delaware Department of Natural Resources and Environmental Control	86	61	85	70	57	85	74	10	73	84	99
Florida Department of Environmental Protection	73	64	88		0	99	86	22	81	44	99
Fond du Lac Band of Lake Superior Chippewa											
Georgia Department of Natural Resources	79	92	91	54	49	99	95	27		5	
Gila River Indian Community											
Hawaii Department of Health Clean Air Branch	50	100	87	91	90	98	80	31	28	11	93
Idaho Department of Environmental Quality	76	99	92	29	33	99	86	6	17	9	2
Illinois Environmental Protection Agency	99	99	97	100	92	100	99	98	98	94	100

Agency	CO	NH3	NOX	PM10	PM2.5	SO2	VOC	Lead	HAP VOC	HAP Metals	Acid Gases
Indiana Department of Environmental Management	97	75	96			100	84	81	63	68	97
Iowa Department of Natural Resources	91	93	97	99	97	100	99	65	96	66	100
Kansas Department of Health and Environment	87	96	96			100	94	21	89	45	100
Kentucky Division for Air Quality	96		99			100	99	67	76	57	21
Knox County Department of Air Quality Management	89		100	0		100	99	89	79	53	32
Louisiana Department of Environmental Quality	93	94	98			92	98	49	89	61	66
Louisville Metro Air Pollution Control District	66	91	93	99	99	100	97	55	83	93	100
Maine Department of Environmental Protection	86	100	97	0		99	95	33	89	74	71
Maricopa County Air Quality Department											
Maryland Department of the Environment	48	43	85	0	0	99	63	35	45	43	100
Massachusetts Department of Environmental Protection	39	96	82			76	82	4	3	2	14
Memphis and Shelby County Health Department - Pollution Control	51	20	56	19	3	98	79	37	71	39	100
Metro Public Health of Nashville/Davidson County	26		61	90	63	92	83		59	7	100
Michigan Department of Environmental Quality	88	65	97	23	17	100	97	50	77	71	98
Minnesota Pollution Control Agency	76	92	96	11	0	99	96	56	91	90	100
Mississippi Dept of Environmental Quality	82	72	92	2	2	100	93	34	90	37	100
Missouri Department of Natural Resources	93	96	97	32	24	100	96	58	87	54	98
Montana Department of Environmental Quality	73	9	95			100	94	47	0	44	0
Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	100		100	100	7	100	100		100		
Navajo Nation											
Nebraska Environmental Quality	84	95	95	34	15	100	92	30	75	36	10
Nevada Division of Environmental Protection	92		98	99		100	95	31		14	

Agency	CO	NH3	NOX	PM10	PM2.5	SO2	VOC	Lead	HAP VOC	HAP Metals	Acid Gases
New Hampshire Department of Environmental Services	67	95	93			99	70	31	50	87	2
New Jersey Department of Environment Protection	48	100	78	94	93	92	91	36	60	49	34
New Mexico Environment Department Air Quality Bureau	90	55	98	97	91	99	94	11	69	12	93
New York State Department of Environmental Conservation	58	84	82	94	87	98	82	25	73	78	97
Nez Perce Tribe	100		100	100	100	100	100	100	100	99	100
North Carolina Department of Environment and Natural Resources	74	90	91	94	83	99	93	33	91	78	99
North Dakota Department of Health	83	73	98	0	0	100	93	38	86	45	100
Northern Cheyenne Tribe											
Ohio Environmental Protection Agency	94	94	98			100	97	44	29	76	95
Oklahoma Department of Environmental Quality	90	80	95	94	80	98	94	62	78	70	94
Omaha Tribe of Nebraska											
Oregon Department of Environmental Quality	78		86	97	59	98	94	20		8	0
Pennsylvania Department of Environmental Protection	84	89	98			100	96	69	87	55	100
Puerto Rico	58		97	98	96	97	57	61		11	
Rhode Island Department of Environmental Management	63	90	74	85	37	74	79	5	74	21	82
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	100		100	100		100	100		100		
South Carolina Department of Health and Environmental Control	94	98	95	98	90	97	97	45	95	71	100
South Dakota Department of Environment and Natural Resources	65		98	66	64	100	96				
Southern Ute Indian Tribe	91		99	95		92	97		91		
Tennessee Department of Environmental Conservation	90	37	98	86	60	100	98	33	91	70	99
Texas Commission on Environmental Quality	100	54	100	100	91	100	100	96	90	75	99
Tohono O-Odham Nation Reservation											
Utah Division of Air Quality	83	96	97	99	97	100	91	0	7	0	97

Agency	CO	NH3	NOX	PM10	PM2.5	SO2	VOC	Lead	HAP VOC	HAP Metals	Acid Gases
Ute Indian Tribe of the Uintah & Ouray Reservation, Utah											
Vermont Department of Environmental Conservation	56		76	87	85	91	82	0	42	0	8
Virgin Islands											
Virginia Department of Environmental Quality	71	79	91	96	78	88	87	56	57	40	99
Washington State Department of Ecology	84	77	88	93	90	97	91	15	28	42	23
Washoe County Health District	1	91	4	18	12	3	79				
West Virginia Division of Air Quality	92	76	99			100	96	67	86	84	100
Wisconsin Department of Natural Resources	80	75	89	97	14	98	97	24	88	74	95
Wyoming Department of Environmental Quality	97	100	99	99	88	100	99	21	91	55	99
Yakama Nation Reservation	100		100	100	52	100	100				

Table 2-4: Nonpoint inventory percentange submitted by reporting agency to total emissions mass

Agency	CO	NH3	NOX	PM10	PM2.5	SO2	VOC	Lead	HAP VOC	HAP Metals	Acid Gases
Alabama Department of Environmental Management											
Alaska Department of Environmental Conservation	4		9	0	0	4	1				
Arizona Department of Environmental Quality	27	2	16	1	7	37	63	6	14	2	
Arkansas Department of Environmental Quality	20	1	19	6		8	1	8	0	2	
Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	100	100	100	42	60	100	100	100	100	98	
California Air Resources Board	32	51	89	76	55	70	47	46	51	65	57
Chattanooga Air Pollution Control Bureau (CHCAPCB)	6	6	25	0	0	5	75	13	4	3	
City of Albuquerque	31	27	82	1	3	87	2	13	0	3	
Clark County Department of Air Quality and Environmental Management	19	5	43	73	78	99	0				
Coeur d'Alene Tribe	5	71	15	83	48	19	41	100	14	98	100
Colorado Department of Public Health and Environment	49		66	1	3		66				
Connecticut Department of Energy and Environmental Protection	9	3	35	4	8	9	71	24	19	34	

Agency	CO	NH3	NOX	PM10	PM2.5	SO2	VOC	Lead	HAP VOC	HAP Metals	Acid Gases
DC-District Department of the Environment	33	2	53	1	3	11	90	29	6	3	
Delaware Department of Natural Resources and Environmental Control	89	98	95	91	94	94	96	66	43	7	
Florida Department of Environmental Protection	7	1	15	4	17	29	63	24	60	1	
Georgia Department of Natural Resources	69	2	23	5	25	42	38				
Hawaii Department of Health Clean Air Branch											
Idaho Department of Environmental Quality	21	75	34	49	57	65	80	95	47	98	100
Illinois Environmental Protection Agency	89	99	69	67	79	98	94	71	56	80	100
Indiana Department of Environmental Management	3	0	20	0	1	12	10	44	10	38	
Iowa Department of Natural Resources	10	0	20	49	52	18	41	65	5	36	
Kansas Department of Health and Environment	1	0	3	0	0	70	19	25	2	7	
Kentucky Division for Air Quality											
Knox County Department of Air Quality Management	18	4	38	6	12	41	81	15	5	3	
Kootenai Tribe of Idaho	7	83	20	85	52	11	52	100	18	94	100
Louisiana Department of Environmental Quality	10	0	4	3	13	32	26	12	4	1	
Louisville Metro Air Pollution Control District	15	5	40	13	32	50	48	7	4	2	
Maine Department of Environmental Protection	4	27	32	2	4	18	60	30	5	5	29
Maricopa County Air Quality Department	4		15	83	53	2	22				
Maryland Department of the Environment	59	8	75	93	81	81	88	77	25	33	10
Massachusetts Department of Environmental Protection	12	59	62	70	39	91	45				
Memphis and Shelby County Health Department - Pollution Control	21	4	70	3	8	31	1	71	0	2	
Metro Public Health of Nashville/Davidson County	13		51	39		9	39	43	34	62	0
Michigan Department of Environmental Quality	77	13	91	10	38	91	92	86	30	77	53

Agency	CO	NH3	NOX	PM10	PM2.5	SO2	VOC	Lead	HAP VOC	HAP Metals	Acid Gases
Minnesota Pollution Control Agency	90	2	41	15	49	75	77	75	54	81	39
Mississippi Dept of Environmental Quality											
Missouri Department of Natural Resources	4	0	34	0	1	11	20	75	0	45	
Montana Department of Environmental Quality											
Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	100		100	100	100	100	100	100	45	32	100
Nebraska Environmental Quality											
Nevada Division of Environmental Protection											
New Hampshire Department of Environmental Services	6	3	88	46	28	95	33				
New Jersey Department of Environment Protection	29	80	85	80	58	93	91				
New Mexico Environment Department Air Quality Bureau											
New York State Department of Environmental Conservation	14	2	67	26	32	82	85	94	30	92	6
Nez Perce Tribe	8	91	22	92	71	32	52	100	19	99	100
North Carolina Department of Environment and Natural Resources	36	0	32	7	26	22	2	4	2	8	92
North Dakota Department of Health											
Northern Cheyenne Tribe	100		100	100	99	100	100	99		72	
Ohio Environmental Protection Agency	9	0	37	1	4	36	75	52	12	33	78
Oklahoma Department of Environmental Quality	50	0	76	1	6	68	87	33	2	43	0
Oregon Department of Environmental Quality	44	2	30	2	11	60	69	16	22	4	
Pennsylvania Department of Environmental Protection	12	1	53	5	13	11	60	3	8	1	
Puerto Rico	0		4	0	0	1	0	0		0	
Rhode Island Department of Environmental Management	3	3	14	1	2	10	24	11	6	31	
Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	100	100	100	14	25	100	100	100	22	99	100

Agency	CO	NH3	NOX	PM10	PM2.5	SO2	VOC	Lead	HAP VOC	HAP Metals	Acid Gases
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	100	100	100	97	90	100	100	100	100	99	100
South Carolina Department of Health and Environmental Control	9	1	23	5	18	13	63	4	4	0	
South Dakota Department of Environment and Natural Resources											
Tennessee Department of Environmental Conservation	11	1	18	7	15	6	0	86	0	31	
Texas Commission on Environmental Quality	61	1	99	2	12	89	94	15	2	17	
United Keetoowah Band of Cherokee Indians in Oklahoma		100									
Utah Division of Air Quality	55	26	76	17	22	19	82				
Vermont Department of Environmental Conservation	88	11	56	35	72	95	50	26	59	8	
Virgin Islands											
Virginia Department of Environmental Quality	14	5	36	4	14	67	68	73	51	30	3
Washington State Department of Ecology	81	4	83	82	83	93	19	12	27	1	99
Washoe County Health District	96	17	99	94	72	100	78	94	3	85	100
West Virginia Division of Air Quality	46	0	70	2	8	79	91	9	83	34	0
Wisconsin Department of Natural Resources	10	0	37	2	8	23	53	28	4	21	
Wyoming Department of Environmental Quality	40		43	1	3	95	81		69		

2.4 What are the top sources of some key pollutants?

Table 2-5 provides a summary of CAP and total HAP emissions for all EIS sectors, including the biogenic emissions from vegetation and soil. Emissions in federal waters and from vegetation and soils have been split out and totals both with and without these emissions are included. Emissions in federal waters include offshore drilling platforms and commercial marine vessel emissions outside the typical 3-10 nautical mile boundary defining state waters. All emissions values are bounded by the caveats and methods described by this documentation.

Table 2-5: EIS sectors and associated 2014v2 CAP emissions and total HAP (1000 short tons/year)

Sector	CO	NH_3	NO_X	$PM_{2.5}$	PM_{10}	SO_2	VOC	Black Carbon	Lead	Total HAPs[1]
Agriculture - Crops & Livestock Dust				986	5,001			11		
Agriculture - Fertilizer Application		787								
Agriculture - Livestock Waste		2,075		4.16	23		180	0.21	2.63E-04	15
Bulk Gasoline Terminals	0.93	4.12E-04	0.45	0.03	0.04	8.01E-03	125	3.58E-04	2.01E-04	6.13
Commercial Cooking	33			89	96		16	2.98	4.79E-05	6.79

Sector	CO	NH_3	NO_X	$PM_{2.5}$	PM_{10}	SO_2	VOC	Black Carbon	Lead	Total HAPs[1]
Dust - Construction Dust	0.07		0.08	125	1,209	0.02	0.04	5.37E-05	1.08E-03	0.07
Dust - Paved Road Dust				179	783			1.86		
Dust - Unpaved Road Dust				660	6,642			0.64		
Fires - Agricultural Field Burning	583	93	20	65	87	6.43	40	7.04	2.23E-04	26
Fires - Prescribed Fires	8,681	138	152	781	920	72	1,980	79		384
Fires - Wildfires	10,487	172	119	886	1,046	71	2,466	84		451
Fuel Comb - Comm/Institutional - Biomass	19	0.19	8.55	12	14	0.93	0.69	0.43	2.85E-04	0.37
Fuel Comb - Comm/Institutional - Coal	3.56	0.01	9.27	0.81	1.90	35	0.29	0.03	1.59E-03	1.39
Fuel Comb - Comm/Institutional - Natural Gas	133	1.47	165	5.12	5.42	1.44	11	0.34	1.94E-03	1.07
Fuel Comb - Comm/Institutional - Oil	12	0.49	48	4.45	4.78	20	2.80	0.60	1.12E-03	0.18
Fuel Comb - Comm/Institutional - Other	11	0.06	12	0.63	0.66	1.21	1.16	0.04	3.52E-04	0.21
Fuel Comb - Electric Generation - Biomass	22	0.74	12	1.73	2.04	1.80	1.04	0.06	1.42E-03	1.60
Fuel Comb - Electric Generation - Coal	579	8.90	1,516	147	195	3,155	22	6.01	0.04	64
Fuel Comb - Electric Generation - Natural Gas	90	13	146	24	25	8.74	9.28	1.65	9.16E-04	3.33
Fuel Comb - Electric Generation - Oil	9.22	0.78	72	6.79	8.13	63	1.70	1.45	1.49E-03	0.38
Fuel Comb - Electric Generation - Other	31	2.20	25	2.88	3.25	16	3.68	0.16	9.42E-04	1.79
Fuel Comb - Industrial Boilers, ICEs - Biomass	303	3.01	115	149	177	20	9.62	5.51	7.1E-03	6.31
Fuel Comb - Industrial Boilers, ICEs - Coal	34	0.73	119	13	41	335	0.88	0.54	0.01	12
Fuel Comb - Industrial Boilers, ICEs - Natural Gas	317	8.29	601	23	24	16	61	1.52	3.03E-03	21
Fuel Comb - Industrial Boilers, ICEs - Oil	25	0.34	83	6.28	7.29	27	5.29	1.38	0.02	0.53
Fuel Comb - Industrial Boilers, ICEs - Other	110	0.87	57	13	14	51	8.81	0.87	2.72E-03	2.48
Fuel Comb - Residential - Natural Gas	98	48	228	3.84	4.10	1.50	14	0.26	1.27E-04	0.86
Fuel Comb - Residential - Oil	9.91	1.88	36	4.03	4.63	57	1.26	0.47	2.59E-03	0.09
Fuel Comb - Residential - Other	13	0.14	35	0.24	0.29	1.85	1.45	0.02	4.78E-06	0.06
Fuel Comb - Residential - Wood	2,108	15	31	315	316	7.71	340	18	8.32E-05	58
Gas Stations	0.04	1.87E-04	0.01	9.07E-04	9.08E-04	4.6E-04	438	4.E-05	2.05E-04	58
Industrial Processes - Cement Manufacturing	99	1.08	118	7.50	13	41	13	0.21	3.11E-03	3.27
Industrial Processes - Chemical Manufacturing	151	23	72	16	21	133	85	0.38	2.99E-03	28
Industrial Processes - Ferrous Metals	350	0.22	60	29	36	26	14	0.53	0.05	2.11
Industrial Processes - Mining	11	0.10	5.50	53	383	1.14	1.34	0.07	4.91E-03	0.84
Industrial Processes - NEC	183	16	171	81	142	137	190	1.42	0.05	47
Industrial Processes - Non-ferrous Metals	268	0.62	16	13	17	67	14	0.20	0.03	6.56
Industrial Processes - Oil & Gas Production	688	0.35	709	20	20	81	3,104	0.11	8.28E-04	109
Industrial Processes - Petroleum Refineries	48	2.45	69	17	19	58	53	1.01	2.91E-03	9.86
Industrial Processes - Pulp & Paper	100	5.30	74	32	41	29	126	0.92	4.01E-03	53
Industrial Processes - Storage and Transfer	6.87	5.39	5.74	17	45	2.97	201	0.24	3.E-03	12
Miscellaneous Non-Industrial NEC	243	5.02	7.05	15	18	0.19	85	0.62	5.81E-04	18
Mobile - Aircraft	412		147	9.30	11	17	47	7.17	0.46	13
Mobile - Commercial Marine Vessels	66	0.16	420	11	12	48	11	5.36	1.1E-03	1.23
Mobile - Locomotives	124	0.38	712	20	22	0.84	37	16	1.82E-03	3.06
Mobile - Non-Road Equipment - Diesel	577	1.39	1,099	83	86	2.06	114	64		52
Mobile - Non-Road Equipment - Gasoline	11,668	0.85	235	50	55	1.16	1,537	6.09		485
Mobile - Non-Road Equipment - Other	415	0.01	67	2.20	2.20	0.45	14	0.40		2.40
Mobile - On-Road Diesel Heavy Duty Vehicles	652	6.67	2,115	92	127	3.44	162	52	2.05E-04	33
Mobile - On-Road Diesel Light Duty Vehicles	520	1.10	173	7.16	9.99	0.37	52	4.73	4.89E-05	9.20
Mobile - On-Road non-Diesel Heavy Duty Vehicles	784	1.03	81	1.64	4.14	0.53	36	0.27	2.2E-05	10
Mobile - On-Road non-Diesel Light Duty Vehicles	22,482	100	2,510	62	163	24	1,966	12	1.53E-03	545
Solvent - Consumer & Commercial Solvent Use				0.01	0.01		1,621	5.33E-04		213
Solvent - Degreasing	5.35E-03	0.04	0.01	0.08	0.08	2.95E-05	172	5.44E-04	3.84E-04	72
Solvent - Dry Cleaning	1.57E-03		7.44E-04	9.38E-03	9.42E-03	4.21E-05	6.18	1.19E-04		0.84
Solvent - Graphic Arts	0.11	0.08	0.13	0.13	0.14	0.02	388	1.E-03	2.61E-05	29
Solvent - Industrial Surface Coating & Solvent Use	5.68	0.45	2.82	3.67	4.12	0.17	539	0.06	2.52E-03	73
Solvent - Non-Industrial Surface Coating		0.02					326			44
Waste Disposal	1,974	29	110	231	278	32	227	24	0.01	45

Sector	CO	NH_3	NO_X	$PM_{2.5}$	PM_{10}	SO_2	VOC	Black Carbon	Lead	Total HAPs[1]
Sub Total (no federal waters)	**65,537**	**3,571**	**12,589**	**5,381**	**18,183**	**4,674**	**16,883**	**424**	**0.73**	**3,043**
Fuel Comb - Industrial Boilers, ICEs - Natural Gas	48	6.71E-03	42	0.39	0.39	0.03	0.99	0.03	1.05E-06	
Fuel Comb - Industrial Boilers, ICEs - Oil	1.17	5.62E-06	5.03	0.25	0.25	0.44	0.27	0.19	7.38E-07	
Fuel Comb - Industrial Boilers, ICEs - Other	1.E-03	3.36E-05	1.25E-03	6.39E-05	6.39E-05	1.64E-05	4.21E-04	4.92E-06	5.25E-09	
Industrial Processes - Oil & Gas Production	1.22	8.07E-03	1.68	0.03	0.03	0.04	46	5.7E-05	1.28E-06	
Industrial Processes - Storage and Transfer							0.88			
Mobile - Commercial Marine Vessels	111	0.28	825	24	26	127	27	7.59	1.91E-03	1.21
Sub Total (federal waters)	**161**	**0.29**	**874**	**25**	**26**	**128**	**76**	**7.81**	**1.92E-03**	**1.21**
Sub Total (all but vegetation and soil)	**65,698**	**3,572**	**13,463**	**5,406**	**18,210**	**4,802**	**16,958**	**431**	**0.73**	**3,044**
Biogenics - Vegetation and Soil[2]	6,654	22	903				38,672			5,294
Total	**72,353**	**3,594**	**14,366**	**5,406**	**18,210**	**4,802**	**55,630**	**431**	**0.73**	**8,338**

[1] Total HAP does not include diesel PM, which is not a HAP listed by the Clean Air Act.

[2] Biogenic vegetation and soil emissions excludes emissions from Alaska, Hawaii, and territories.

2.5 How does this NEI compare to past inventories?

Many similarities exist between the 2014 NEI approaches and past NEI (including 2014v1) approaches, notably that the data are largely compiled from data submitted by S/L/T agencies for CAPs, and that the HAP emissions are augmented by the EPA to differing degrees depending on geographical jurisdiction because they are a voluntary contribution from the partner agencies. In 2014, S/L/T participation was somewhat more comprehensive than in 2011, though both were good. The NEI program continues with the 2014 NEI to work towards a complete compilation of the nation's CAPs and HAPs. The EPA provided feedback to S/L/T agencies during the compilation of the data on critical issues (such as potential outliers, missing SCCs, missing Hg data and coke oven data) as has been done in the past, collected responses from S/L/T agencies to these issues, and improved the inventory for the release based on S/L/T agency feedback. In addition to these similarities, there are some important differences in how the 2014 NEI has been created and the resulting emissions, which are described in the following two subsections.

2.5.1 Differences in approaches

With any new inventory cycle, changes to approaches are made to improve the process of creating the inventory and the methods for estimating emissions. The key changes for the 2014 cycle are highlighted here.

To improve the process, we learned from the prior two triennial inventories (for 2008 and 2011) compiled with the EIS. We made changes to pollutant and SCC codes, refined quality assurance checks and features that were used to assist in quality assurance, and created a Nonpoint Survey to assist with S/L/T and EPA data reconciliation for the nonpoint data. The nonpoint survey helped S/L/Ts and EPA avoid double counting and ensure a complete inventory between the different sources of data.

In addition to process changes, we improved emissions estimation methods for all data categories. For point sources, the primary changes were our use of HAP emission rates for EGUs, HAP augmentation improvements, and the use of an expected pollutant QA check. For EGUs, we chose to defer to S/L/T-provided HAP data rather than override their submissions using emission factors developed from the Mercury and Air Toxics Standards (MATS) test program as we had done in 2008 and 2011. Instead, we provided these the HAP emission factors to S/L/T agencies so their inventory staff could use them. HAP augmentation improvements are described in Section 3.1.6 and the expected pollutant QA is described in Section 3.1.1. More information on point source improvements is available in Section 3.

We also made method improvements for many stationary nonpoint sectors (see also in Section 4). The EPA creates and provides emissions tools to S/L/T agencies for their use, and we use these tools ourselves to fill in emissions values where not provided by S/L/T/ agencies. We updated methods for residential wood combustion to improve the geographic allocation of appliances, burn rates and controls. We updated the agricultural livestock ammonia method to reflect a new method devised by researchers to incorporate more process-based methods and new observational data. We updated the approach for agricultural tilling to use USDA Census of Agriculture data on harvested acres and tillage type rather than a national top-down approach. We refined emissions calculation approaches for the oil and gas exploration and production sectors to reflect new processes and made use of newly available data. For all nonpoint categories except for nonpoint mercury sectors, we updated the activity data to use the newest data available, at the time, to represent the 2014 inventory year.

One method change was made for road dust that was not an improvement in 2014v1, but was fixed in the 2014v2 NEI. In 2014v1, we did not use a "precipitation" adjustment for road dust that was included in the 2011 NEI. We removed this adjustment because air quality modelers use gridded meteorology, soil moisture, snow cover and other parameters to remove (zero out) dust emissions on an hourly basis, and we did not want to have this effect applied twice in air quality modeling -and using two likely-different methods. The 2011 precipitation adjustment is essentially smoothed over the entire year and used different (not gridded, temporally-resolved) data. However, the resulting 2014v1 emissions did not reflect the actual emissions associated from the road dust processes, and caused a significant increase in PM emission trends from prior NEIs. Therefore, as discussed in greater detail in Section 4.9.3.5 and Section 4.10.3.5, we re-applied a meteorological adjustment, based on 2014v1 emissions modeling, to paved and unpaved road dust PM estimates for the 2014v2 NEI.

For mobile sources, we updated mobile source activity data such as vehicle miles travelled (VMT) to reflect 2014, we used updated mobile source models, and we used new mobile model inputs provided by S/L/T agencies and other sources. Sections 5 and 6 provide more detail on these improvements.

We also made several improvements to approaches for fire sources, as further described in Section 7. For agricultural fires, we used an improved satellite-based approach and added a distinction between grass and pasture burning processes. For wildfires and prescribed fires, we used 2014-specific satellite data and collected 2014-specific ground based observational data from many state forestry agencies. For these fires, we also estimated the flaming and smoldering components of emissions separately and retained this delineation in the final inventory. Finally, we revised several HAP emission factors based on the peer reviewed literature.

2.5.2 Differences in emissions between 2014 and 2011 NEI

This section presents a comparison from the 2011v2 NEI to the 2014v2 NEI. Table 2-6 and Table 2-7 compare emissions for the CAPs for the 2014v2 minus 2011v2 NEI, and for 2014v2 minus 2014v1 NEIs, respectively, for seven highly aggregated emission sectors. Table 2-8 and Table 2-9 compare emissions for select HAPs for the 2014v2 minus 2011v2 NEI, and for 2014v2 minus 2014v1 NEIs, respectively, for the same seven highly aggregated emission sectors. Emissions from the biogenic (natural) sources are excluded, and the wildfire sector is shown separately for CAPs and HAPs. While Pb is a CAP for the purposes of the NAAQS, due to toxic attributes and inclusion in previous national air toxics assessments (NATA), it is reviewed here with the HAPs. The HAPs selected for comparison are based on their national scope of interest as defined by NATA.

With a couple notable exceptions, CAP emissions are lower overall in 2014 (v2) than in 2011 (v2). Some specific sector/pollutants increased in 2014 from 2011. The increases in industrial processes VOC is off-set by more substantial cumulative decreases in fuel combustion and mobile sources. A small increase in fuel combustion

NH_3 is more than offset by large reductions from agriculture (miscellaneous) sources. Mobile source sector emissions are lower in 2014 than 2011, continuing a trend found between 2008 and 2011. Wildfire CAP emissions are lower in 2014 than in 2011, which is consistent with the general observation that 2014 was a generally quiet year for such fires. CAP emission increases in 2014 occur for the following sectors:

- Fuel Combustion – natural gas from residential and industrial boilers and internal combustion engines (NH_3)
- Industrial Processes – oil and gas production (VOC).

Table 2-6: Emission differences (tons) for CAPs, 2014v2 minus 2011v2 NEIs

Broad Sector	CO	NH_3	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC
Fuel Combustion	-530,653	3,989	-454,859	-110,138	-92,874	-1,623,060	-111,203
Industrial Processes	-176,239	-13,238	-9,576	-127,551	-40,273	-91,126	334,910
Miscellaneous	-697,269	-610,108	-6,942	-1,918,556	-277,869	-6,519	-247,245
Highway Vehicles	-2,918,889	-15,012	-991,212	-66,557	-34,435	-1,062	-426,178
Nonroad Mobile	-1,687,099	-484	-401,334	-36,213	-34,603	-58,228	-396,832
Total Difference, excluding wildfires	**-6,010,149**	**-634,852**	**-1,863,923**	**-2,259,015**	**-480,054**	**-1,779,994**	**-846,549**
Total % Difference, excluding wildfires	-10%	-16%	-13%	-12%	-10%	-28%	-6%
Wildfires	-2,214,402	-31,661	-65,655	-280,235	-238,930	-24,388	-425,060

Table 2-7: Emission differences (tons) for CAPs, 2014v2 minus 2014v1 NEIs

Broad Sector	CO	NH_3	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC
Fuel Combustion	-66,060	-1,305	-41,593	-61,035	-36,336	-135,515	-13,938
Industrial Processes	-157,427	83	-104,621	-96,786	-10,827	9,101	-71,681
Miscellaneous	-207,110	-303,021	-3,871	-6,169,504	-806,974	-4,566	299,211
Highway Vehicles	2,601,462	4,367	213,927	-5,562	3,800	-227	163,429
Nonroad Mobile	-44,726	-25	-117,556	-5,367	-5,044	-6,802	-8,677
Total Difference, excluding wildfires	**2,126,138**	**-299,900**	**-53,715**	**-6,338,255**	**-855,380**	**-138,008**	**368,344**
Total % Difference, excluding wildfires	4%	-8%	0%	-27%	-16%	-3%	3%
Wildfires	160,312	2,622	1,569	15,770	13,356	1,015	37,649

There are various changes in CAP emissions between 2014v1 and 2014v2. The most significant increases are in onroad mobile and wildfires. The increase in industrial processes SO2 is from an increase in S/L/T-submitted chemical manufacturing emissions. Roughly half the increase in miscellaneous VOC is from the introduction of VOC for livestock waste and the rest from solvent utilization. The biggest change between 2014v1 and 2014v2 was the reintroduction of the precipitation reduction to unpaved and paved road dust for PM.

For the select HAPs reviewed, Table 2-8 indicates a mixture of overall increases and decreases between 2011 and 2014, with the largest increases in some VOC HAPs for industrial, miscellaneous and nonroad sources. Some of the largest decreases are for highway vehicle VOC HAPs and fuel combustion. VOC HAPs increase for nonroad mobile sources mostly result from using a new model (MOVES2014 rather than NONROAD) and newer emission factors for nonroad equipment in 2014 and resulting different emissions factors in MOVES2014. Unlike CAPs, updated HAP emission factors from wildfires result in some HAP emissions that are higher in 2014 than in 2011, with the most substantial increase for formaldehyde. HAP emission increases in sectors, include the following:

- Fuel Combustion – biomass, coal and oil combustion (Pb).
- Industrial Processes –oil and gas production (VOC HAPs)

- Miscellaneous - agricultural field burning and prescribed fires (acrolein), construction and road dust (Pb)
- Nonroad Mobile – aircraft and gasoline, diesel and other equipment (acrolein, formaldehyde)

There were smaller changes in HAPs between 2014v1 and 2014v2. As seen in Table 2-9, the largest increases in 2014v2 are from highway vehicles and new HAP estimates for wildfires and prescribed burning sources. Sizable decreases in miscellaneous sources are from agricultural field burning and solvents and decreases in industrial processes are from oil and gas sources.

Table 2-8: Emission differences (tons) for select HAPs, 2014v2 minus 2011v2 NEIs

Broad Sector	Acrolein	Benzene	Ethylene Oxide	Formaldehyde	Hexavalent Chromium	Lead
Fuel Combustion	-245	-3,616	-8	-3,647	-14	13
Industrial Processes	350	3,881	-57	8,712	-17	-72
Miscellaneous	3,665	-33,759	-79	-2,632	0	3
Highway Vehicles	-467	-10,271		-5,812	0	
Nonroad Mobile	2,205	-844		16,170	-1	-31
Total Difference, excluding wildfires	**5,508**	**-44,609**	**-145**	**12,791**	**-32**	**-87**
Total % Difference, excluding wildfires	19%	-20%	-49%	5%	-46%	-11%
Wildfires	737	-29,726		3,550		

Table 2-9: Emission differences (tons) for select HAPs, 2014v2 minus 2014v1 NEIs

Broad Sector	Acrolein	Benzene	Ethylene Oxide	Formaldehyde	Hexavalent Chromium	Lead
Fuel Combustion	-15	-954	0	-1,151	0	2
Industrial Processes	-78	-1,174	-38	-363	-5	0
Miscellaneous	-1,761	-3,433	-2	-3,349	-16	0
Highway Vehicles	151	5,394		1,851	0	0
Nonroad Mobile	-47	-88		-639	0	0
Total Difference, excluding wildfires	**-1,749**	**-254**	**-40**	**-3,651**	**-22**	**3**
Total % Difference, excluding wildfires	-5%	0%	-21%	-1%	-36%	0%
Wildfires	542	447		3,518		

2.6 How well are tribal data and regions represented in the 2014 NEI?

Twelve tribes submitted data to the EIS for 2014 as shown in Table 2-10. In this table, a "CAP, HAP" designation indicates that both criteria and hazardous air pollutants were submitted by the tribe. CAP indicates that only criteria pollutants were submitted. Facilities on tribal land were augmented using TRI, HAPs and PM in the same manner as facilities under the state and local jurisdictions, as explained in Section 3.1, therefore, Tribal Nations in Table 2-10 with just a CAP flag will also have some HAP emissions in most cases.

Seven additional tribal agencies, shown in Table 2-11, which did not submit any data, are represented in the point data category of the 2014 NEI due to the emissions added by the EPA. The emissions for these facilities are from the EPA gap fill datasets for airports, EGUs, TRI data, and data carried forward from the 2011 NEI that were not provided in the 2014 submittal. Furthermore, many nonpoint datasets included in the NEI are presumed to include tribal activity. Most notably, the oil and gas nonpoint emissions have been confirmed to include activity on tribal lands because the underlying database contained data reported by tribes. See Section 4.16 for more information.

Table 2-10: Tribal participation in the 2014 NEI

Tribal Agency	Point	Nonpoint	Onroad	Nonroad
Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	CAP, HAP	CAP, HAP		
Coeur d'Alene Tribe	CAP, HAP	CAP, HAP	CAP, HAP	CAP, HAP
Confederated Tribes of the Colville Reservation, Washington	CAP			
Kootenai Tribe of Idaho		CAP, HAP	CAP, HAP	CAP, HAP
Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	CAP, HAP	CAP, HAP	CAP	
Nez Perce Tribe	CAP, HAP	CAP, HAP	CAP, HAP	CAP, HAP
Northern Cheyenne Tribe		CAP, HAP	CAP	CAP
Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation		CAP, HAP		
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	CAP, HAP	CAP, HAP	CAP, HAP	CAP, HAP
Southern Ute Indian Tribe	CAP, HAP			
United Keetoowah Band of Cherokee Indians in Oklahoma		CAP		
Yakama Nation Reservation	CAP			

Table 2-11: Facilities on Tribal lands with 2014 NEI emissions from EPA only

Tribal Agency	EPA data used
Fond du Lac Band of Lake Superior Chippewa	Airports
Gila River Indian Community	TRI
Navajo Nation	Prior Year NEI Carry-forward, EGUs
Northern Cheyenne Tribe	Airports
Omaha Tribe of Nebraska	Airports
Tohono O-Odham Nation Reservation	TRI
Ute Indian Tribe of the Uintah & Ouray Reservation, Utah	Airports, EGUs

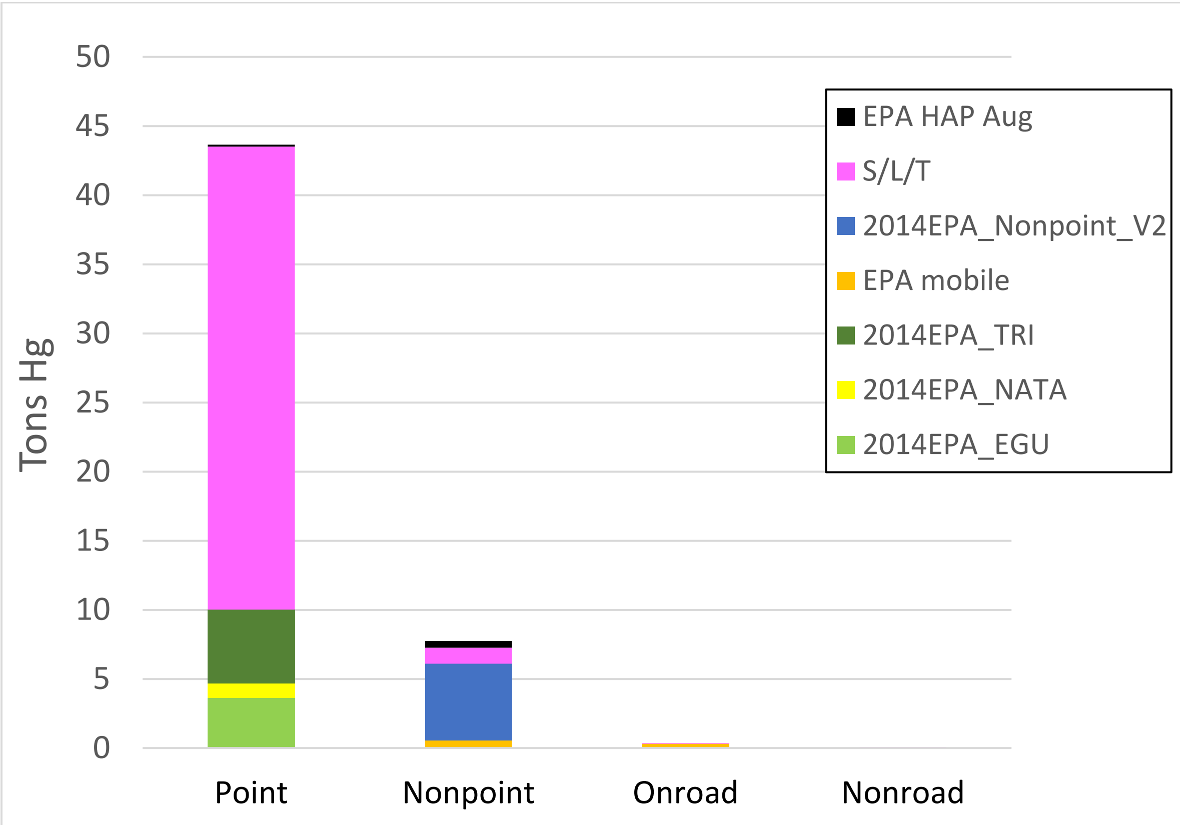
2.7 What does the 2014 NEI tell us about mercury?

This documentation includes this Hg section because of the importance of this pollutant and because the sectors used to categorize Hg are different than the sectors presented for the other pollutants. The Hg sectors primarily focus on regulatory categories and categories of interest to the international community; emissions are summarized by these categories at the end of this section, in Table 2-14.

Mercury emission estimates in the 2014v2 NEI sum to 52 tons, with 51 tons from stationary sources (not including commercial marine vessels and locomotives) and 1 ton from mobile sources (including commercial marine vessels and locomotives). Of the stationary source emissions, the inventory shows that 22.9 tons come from coal, petroleum coke or oil-fired EGUs with units larger than 25 megawatts (MW), with coal-fired units making up the vast majority (i.e., petroleum coke and oil-fired boilers account for less than 0.1 ton) of that total. As with previous NEIs, coal-fired EGUs comprise the largest portion of the mercury emissions in the 2014v2 NEI.

The data sources used to create the 2014 Hg inventory are shown in Figure 2-3.

Figure 2-3: Data sources of Hg emissions (tons) in the 2014v2 NEI, by data category



In the above figure the "EPA mobile" accounts for all EPA datasets containing onroad, nonroad, CMV and locomotive emissions. The 2014EPA_NATA dataset contains EPA revisions to Hg emissions including additional gap filling of emissions not reported by S/L/T and updated railyard emissions.

In addition to Figure 2-3, Table 2-12 lists the emissions by data source with EPA mobile further broken out. More information on the datasets is available in Section 3.1.2 for point, Section 4.1.1 for nonpoint, Section 5 for nonroad mobile, and Section 6 for onroad mobile sources.

Table 2-12: 2014v2 NEI Hg emissions (tons) for each dataset type and group

Data Category	Data Source	Hg emissions
Point	S/L/T	33.5
	2014EPA_TRI	5.4
	2014EPA_EGU	3.6
	EPA NATA	1.0
	EPA HAP Aug	0.1
	2014EPA_LF	0.01
Nonpoint	EPA_Nonpoint_V2	5.5
	S/L/T	1.2
	EPA Rail	0.5
	EPA HAP Aug	0.5
	EPA CMV	0.01

Data Category	Data Source	Hg emissions
Onroad	EPA onroad	0.3
	S/L/T	0.04
Nonroad	S/L/T	0.04
	EPA nonroad	0.02

The datasets are described in more detail starting in Sections 3 and 4, and we highlight some key datasets here.

For EGUs, we gap-filled where S/L/Ts did not provide emissions using unit specific and "bin"-average emission factors collected from a test program conducted primarily in 2010 to support the MATS rule [ref 2], and used 2014-specific activity from the Clean Air Markets Division Data. The MATS-based Hg data are labeled "EPA EGU" in the figure; all mercury emissions from the EPA EGU dataset use MATS-based data.

We gap-filled Hg not reported by S/L/Ts in the same way as other HAPs – including use of the TRI (see Section 3.1.5), EPA HAP Augmentation or "HAP Aug" in the figure (see Section 2.2.3), and other EPA data developed for gap filling (see Section 2.2.5). For 2014v2, however, we conducted additional gap filling for mercury. We used TRI data associated with electric arc furnaces (EAFs) that we had excluded in 2014v1 due to our business rule of not using TRI data at a facility where there were S/L/T-submitted estimates. We determined that for some EAFs, the S/L/T-submitted estimates were not associated with EAFs (they were associated with fuel combustion). In addition, we gap filled EAFs that were not reported by S/L/Ts and for which there was no TRI estimate by applying a 34% reduction to 2011 NEI emissions (process level). The 2011 NEI emissions were based on data developed for the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Area Sources: Electric Arc Furnace Steelmaking Facilities (subpart YYYYY). The 34% value was the average reduction from a limited 3 facility test program in 2016 (the range was 11-70%) -based on personal communication with Donna Lee Jones, EPA lead for the NESHAP.

For municipal waste combustors (MWCs), we compared the 2014v1 estimates with 2015 emissions data on waste-to-energy facilities collected for the "Inventory of U.S. sources of mercury emissions to the atmosphere" [ref 3]. We worked with several states to review their estimates, which led to some changes from their 2014v1 data. We also gap filled MWCs that were missing from the NEI. One MWC unit tested in 2014 was not changed despite it being significantly higher than the 2015 data. It was determined [ref 4] that the 2014 test was influenced by an abnormally high (and not representative) Hg inlet concentration (about 10-100 times higher than average) during the stack test. Because these test data were used for the annual emission factor for the unit, this one facility was estimated to emit approximately 320 lbs out of a total of 1244 lbs (30% of the national total).

For 2014v2, EPA updated the estimates for the nonpoint non-combustion-related and cremation categories; laboratory activities which was carried forward from the 2011 NEI "as-is." The methodologies are described in Section 4. EPA estimates for these categories are included in the "2014EPA_NONPOINT_V2" (along with other EPA nonpoint category estimates) shown in Figure 2-3 and Table 2-12 and include:

- switches and relays – emissions from the shredding and crushing of cars containing Hg components at auto crushing yards, SCC = 2650000002: Waste Disposal, Treatment, and Recovery; Scrap and Waste Materials; Scrap and Waste Materials; Shredding (1.7 tons)
- landfill "working face" emissions associated with the release of mercury via churning/crushing of new material added to the landfill, SCC= 2620030001: Waste Disposal, Treatment, and Recovery; Landfills; Municipal; Dumping/Crushing/Spreading of New Materials (working face) (0.4 tons)

- thermometers and thermostats – the portion that emit mercury prior to disposal at landfills or incinerators, SCC=2650000000: Waste Disposal, Treatment, and Recovery; Scrap and Waste Materials; Scrap and Waste Materials; Total: All Processes (0.1 tons)
- dental amalgam – emissions at dentist offices and from evaporation in teeth, SCC=2850001000: Miscellaneous Area Sources; Health Services; Dental Alloy Production; Overall Process (0.5 tons)
- general laboratory activities, SCC = 2851001000: Miscellaneous Area Sources; Laboratories; Bench Scale Reagents; Total (0.3 tons)
- fluorescent lamp breakage, SCC= 2861000000: Miscellaneous Area Sources; Fluorescent Lamp Breakage; Non-recycling Related Emissions; Total (0.8 tons)
- fluorescent lamp recycling, SCC= 2861000010: Miscellaneous Area Sources; Fluorescent Lamp Breakage; Recycling Related Emissions; Total (less than 1 lb)
- animal cremation, SCC= Miscellaneous Area Sources; Other Combustion; Cremation; Animals (0.07 tons nonpoint plus 0.01 tons point)
- human cremation – emissions primarily due to mercury in dental amalgam, SCC=2810060100: Miscellaneous Area Sources; Other Combustion; Cremation; Humans (1.4 tons nonpoint plus 0.1 tons point)

While most of the data for these categories use the EPA estimates, some S/L/Ts also provide estimates for some of these nonpoint sources. The values in parentheses are the total nonpoint portion except for animal and human cremation which include the component from point sources.

Other nonpoint estimates changed between 2014v1 and 2014v2. Corrections were made from the 2014v1 augmentation of Hg from diesel engines and turbines. An Hg-to-PM2.5-PRI ratio was computed that was consistent with the ICI Combustion Tool (see Section 4.12), resulting in a large decrease in Hg emissions. We updated the approach for residential wood combustion resulting in an increase in Hg emissions.

Since mercury is a HAP, it is reported voluntarily by S/L/T agencies. For the 2014 NEI, S/L/T agencies reported emissions in 42 states for 2014v1, and an additional 3 states provided emissions for 2014v2 that hadn't provided emissions for v1. No tribal agencies reported point source Hg. Table 2-13 identifies the states for which state or local agencies provided data; 16 states (CA, DE, IN, LA, MA, MD, MN, NC, NJ, NY, OH, OR, RI VA, VT, WI, WY) submitted additional emissions or changes to their emissions for 2014v2. In addition, for the 2014v2, KY requested that EPA use EPA EGU Hg estimates ahead of KY state-submitted estimates (no changes were made to the local Louisville agency estimates). Twenty-one states (AZ, CA, CT, DE, ID, IL, LA, MD, ME, MI, MN, NC, NY, OH, OK, OR, RI, VA, VT, WA, WV), 2 local agencies (Washoe County and Memphis) and 10 tribal agencies reported Hg to the nonpoint data category. Seven tribal agencies reported Hg to the nonpoint data category: Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation, Montana; Coeur d'Alene Tribe of the Coeur d'Alene Reservation, Idaho; Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California; Kootenai Tribe of Idaho; Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho; Nez Perce Tribe of Idaho; and Sac & Fox Nation of Missouri in Kansas and Nebraska.

In contrast to the 2011 NEI, most of the point Hg in 2014 is from S/L/Ts and not the EPA EGU dataset. This is because we changed the selection hierarchy to use the S/L/T data ahead of the MATS EFs from the EPA's EGU dataset. Instead, the EPA provided the MATS EFs to S/L/Ts, so that they could use them if they chose.

Table 2-13: Point inventory percentage submitted by reporting agency to State total Hg emissions mass

State	Agency	Agency Type	Percent of State Total
AL	Alabama Department of Environmental Management	State	50
AL	Jefferson County (AL) Department of Health	Local	21
AR	Arkansas Department of Environmental Quality	State	81
AZ	Arizona Department of Environmental Quality	State	90
CA	California Air Resources Board	State	32
CO	Colorado Department of Public Health and Environment	State	39
CT	Connecticut Department of Energy and Environmental Protection	State	99
DE	Delaware Department of Natural Resources and Environmental Control	State	99
FL	Florida Department of Environmental Protection	State	70
HI	Hawaii Department of Health Clean Air Branch	State	38
IA	Iowa Department of Natural Resources	State	97
ID	Idaho Department of Environmental Quality	State	0.4
IL	Illinois Environmental Protection Agency	State	93
IN	Indiana Department of Environmental Management	State	95
KS	Kansas Department of Health and Environment	State	100
KY	Kentucky Division for Air Quality	State	28
KY	Louisville Metro Air Pollution Control District	Local	13
LA	Louisiana Department of Environmental Quality	State	23
MA	Massachusetts Department of Environmental Protection*	State	37
MD	Maryland Department of the Environment*	State	16
ME	Maine Department of Environmental Protection	State	100
MI	Michigan Department of Environmental Quality	State	97
MN	Minnesota Pollution Control Agency	State	100
MO	Missouri Department of Natural Resources	State	98
MS	Mississippi Dept of Environmental Quality	State	85
MT	Montana Department of Environmental Quality	State	3
NC	Forsyth County Office of Environmental Assistance and Protection	Local	0.5
NC	North Carolina Department of Environmental Quality	State	82
NC	Western North Carolina Regional Air Quality Agency (Buncombe Co.)	Local	2
ND	North Dakota Department of Health	State	78
NE	Lincoln/Lancaster County Health Department	Local	2
NE	Nebraska Environmental Quality	State	2
NH	New Hampshire Department of Environmental Services	State	97
NJ	New Jersey Department of Environment Protection	State	90
NV	Nevada Division of Environmental Protection	State	41
NY	New York State Department of Environmental Conservation	State	100
OH	Ohio Environmental Protection Agency	State	82
OK	Oklahoma Department of Environmental Quality	State	95
OR	Oregon Department of Environmental Quality*	State	0.05
PA	Allegheny County Health Department	Local	3
PA	Pennsylvania Department of Environmental Protection	State	88

State	Agency	Agency Type	Percent of State Total
PA	Philadelphia Air Management Services	Local	1
RI	Rhode Island Department of Environmental Management	State	100
SC	South Carolina Department of Health and Environmental Control	State	100
TN	Knox County Department of Air Quality Management	Local	13
TN	Memphis and Shelby County Health Department - Pollution Control	Local	10
TN	Tennessee Department of Environmental Conservation	State	40
TX	Texas Commission on Environmental Quality	State	99
VA	Virginia Department of Environmental Quality	State	45
VT	Vermont Department of Environmental Conservation	State	54
WA	Olympic Region Clean Air Agency	Local	2
WA	Southwest Clean Air Agency	Local	27
WA	Washington State Department of Ecology	State	11
WI	Wisconsin Department of Natural Resources	State	95
WV	West Virginia Division of Air Quality	State	99
WY	Wyoming Department of Environmental Quality	State	67
*Emissions were provided for v2 during the NATA review. The dataset is 2014EPA_NATASLT.			

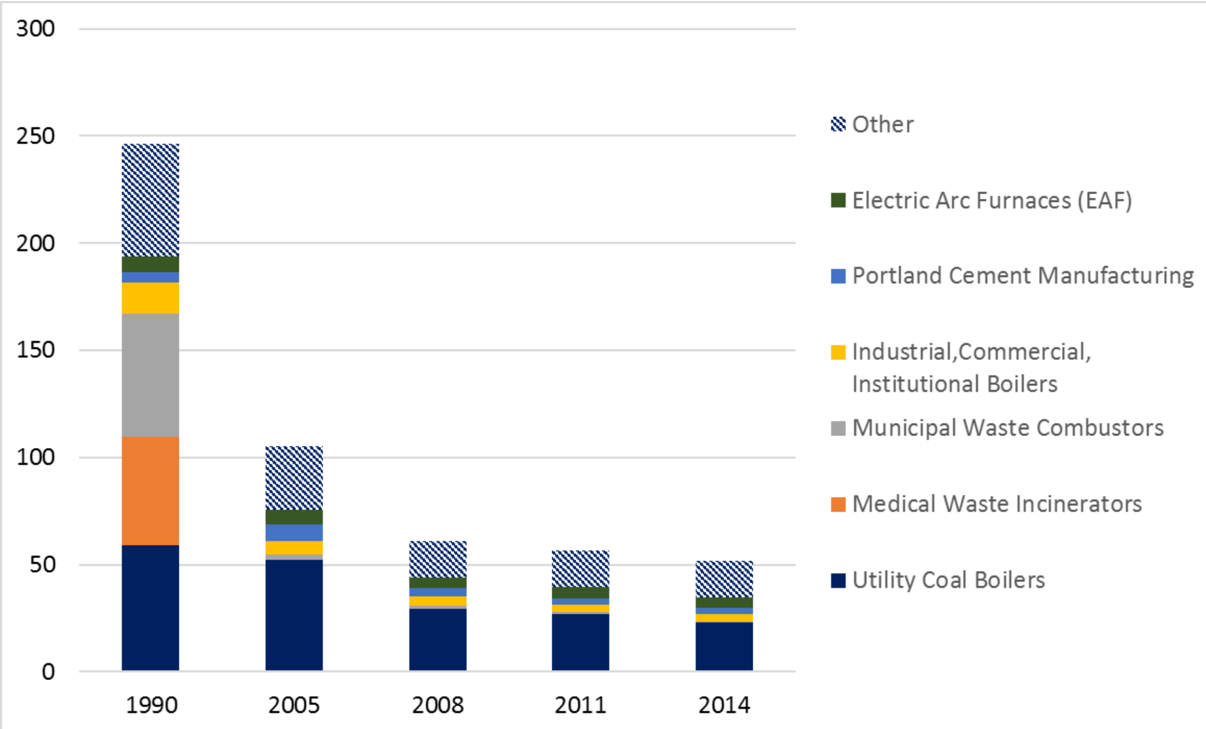
Table 2-14 and Figure 2-4 show the 2014 NEI mercury emissions for the key categories of interest in comparison to 1990. Also shown are the previous 2 triennial NEI years along with the most recent 2005 emissions, which were used in support of the MATS rule. Two Microsoft ® Excel ® databases included in the zip file, 2014nei_supdata_mercury.zip, provides the category assignments at the facility-process level for point sources, the county-SCC level for nonpoint sources, and the county level for onroad and nonroad sources. Individual point source processes were matched to categories based on the process-level or unit-level category assignments used in the 2011v2 NEI. In some cases, manual assignments had to be made where data were not reported by the S/L/Ts and were gap-filled using the TRI. SCC and facility category codes were also used.

Table 2-14: Trends in NEI mercury emissions – 1990, 2005, 2008 v3, 2011v2 and 2014v2 NEI

Source Category	1990 (tpy) Baseline for HAPs, 11/14/2005	2005(tpy) MATS proposal 3/15/2011	2008 (tpy) 2008v3	2011 (tpy) 2011v2	2014 (tpy) 2014v2	Notes
Utility Coal Boilers (Electricity Generation Units – EGUs, combusting coal)	58.8	52.2	29.4	26.8	22.9	This category includes only units > 25 MW. (smaller units are included in boiler and process heater category) Includes coal units (and excludes Hg estimated for startup gas/oil) and 3 integrated gasified coal combustion units.
Hospital/Medical/ Infectious Waste Incineration	51	0.2	0.1	0.1	0.02	Known issues: missing 2 facilities (UT and ND); these would bring the total to 0.03 tons.

Source Category	1990 (tpy) Baseline for HAPs, 11/14/2005	2005(tpy) MATS proposal 3/15/2011	2008 (tpy) 2008v3	2011 (tpy) 2011v2	2014 (tpy) 2014v2	Notes
Municipal Waste Combustors	57.2	2.3	1.3	1.0	0.6	One unit had an abnormally high (and not representative) Hg inlet concentration (about 10-100 times higher than average) during the stack test. If 2015 emissions for that facility were used the total emissions would be 0.5.
Industrial, Commercial/Institutional Boilers and Process Heaters	14.4	6.4	4.2	3.6	3.2	includes electricity generating units where less than 25 MW.
Mercury Cell Chlor-Alkali Plants	10	3.1	1.3	0.5	0.1	
Electric Arc Furnaces	7.5	7.0	4.8	5.4	5.0	Assumed a 34% reduction from 2011 levels for those units that were gap filled due to lack of S/L/T or TRI data.
Commercial/Industrial Sold Waste Incineration	Not available	1.1	0.02	0.01	0.01	
Hazardous Waste Incineration	6.6	3.2	1.3	0.7	0.8	
Portland Cement Non-Hazardous Waste	5.0	7.5	4.2	2.9	3.2	
Gold Mining	4.4	2.5	1.7	0.8	0.6	includes fugitive emissions at mines such as TRI emissions at fugitive release points that were not reported by S/L/T
Sewage Sludge Incineration	2	0.3	0.3	0.3	0.3	
Mobile Sources	Not available	1.2	1.8	1.3	1.0	Sum of all of onroad, nonroad, locomotives and commercial marine vessels
Other Categories	29.5	18	10.7	13	14.0	
Total (all categories)	**246**	**105**	**61**	**56**	**52**	

Figure 2-4: Trends in NEI Mercury emissions (tons)



The top emitting 2014 Mercury categories are: EGUs (rank 1); electric arc furnaces (rank 2); Portland cement (excluding hazardous waste kilns) and industrial, commercial and institutional boilers and process heaters (rank 3).

As shown in Table 2-14, 2014 Hg emissions are 4 tons lower than in the 2011. Almost four tons of this difference is due to lower Hg emissions from EGUs covered by MATS; three other categories with large decreases are industrial, commercial/institutional boilers and process heaters, municipal waste combustors and chlor-alkali plants. The gold mining decrease is somewhat offset by the inclusion of fugitive emissions at gold mines which may have not been fully accounted for in previous inventories. For EGUs, the decrease is a combination of fuel switching to natural gas, the installation of Hg controls to comply with state rules and voluntary reductions, early compliance with MATS, and the co-benefits of Hg reductions from control devices installed for the reduction of SO_2 and PM because of state and federal actions, such as New Source Review enforcement actions. The lower Hg is consistent with a 28 percent decrease in SO_2 from point sources. For industrial and commercial/institutional boilers, there appears to be fewer boilers using coal. In the Hg chlor alkali industries, facilities have been switching technologies to eliminate Hg emissions from chlorine production. Many switched prior to 2008, and in 2014, there were two facilities still using the Hg chlor alkali process.

2.8 References for 2014 inventory contents overview

1. Strait, R.; MacKenzie, D.; and Huntley, R., 2003. PM Augmentation Procedures for the 1999 Point and Area Source NEI, 12th International Emission Inventory Conference – "Emission Inventories – Applying New Technologies", San Diego, April 29 – May 1, 2003.
2. U.S. Environmental Protection Agency, 2011. Memorandum: Emissions Overview: Hazardous Air Pollutants in Support of the Final Mercury and Air Toxics Standard, Office of Air Quality Planning and Standards, EPA-454/R-11-014, November 2011.

3. Bolate, Yenaxika, May 2017. Inventory of U.S. sources of mercury emissions to the atmosphere, Master's Thesis, Department of Earth and Environmental Engineering, Fu Foundation School of Engineering, Columbia University. Advisors: Profs. N.J. Themelis and A.C. Bourtsalas.
4. A.C. (Thanos) Bourtsalas Research Scientist, Earth Engineering Center, Columbia University. Email Athanasios Bourtsalas to Madeleine Strum, 12/21/2017.

3 Point sources

This section provides a description of sources that are in the point data category. Point sources are included in the inventory as individual facilities, usually at specific latitude/longitude coordinates, rather than as county or tribal aggregates. These facilities include large energy and industrial sites, such as electric generating utilities (EGUs), mines and quarries, cement plants, refineries, large gas compressor stations, and facilities that manufacture pulp and paper, automobiles, machinery, chemicals, fertilizers, pharmaceuticals, glass, food products, and other products. Additionally, smaller points sources are included voluntarily by S/L/T agencies, and can include small facilities such as crematoria, dry cleaners, and even gas stations. These smaller sources may appear in one state but not another due to the voluntary nature of providing smaller sources. There are also some portable sources in the point source data category, such as hot mix asphalt facilities, which relocate frequently as a road construction project progresses. The point source data category also includes emissions from the landing and take-off portions of aircraft operations, the ground support equipment at airports, and locomotive emissions within railyards. Within a point source facility, emissions are estimated and reported for individual emission units and processes. Those emissions are associated with any number of stack and fugitive release points that each have parameters needed for atmospheric modeling exercises. Stationary sources that are inventoried at county-resolution are discussed in the Nonpoint Section 4.

The approach used to build the 2014v1 National Emissions Inventory (NEI) for all point sources is discussed in Section 3.1 through Section 3.8. Some changes to aircraft for the 2014v2 NEI are also discussed in Section 3.2, and revisions to rail yard estimates for 2014v2 are included in Section 3.3. A comprehensive discussion of the changes to the 2014v2 point inventory are presented in Section 3.9.

3.1 Point source approach: 2014v1

The general approach to building the NEI point source inventory is to use state/local/tribal (S/L/T)-submitted emissions, locations, and release point parameters wherever possible. Missing emissions values are gap-filled with EPA data where available. Quality assurance reviews of the emission values, locations, and release point modeling parameters are done by the EPA on the most significant emission sources and where data does not pass quality assurance checks.

3.1.1 QA review of S/L/T data

State/local/tribal agency submittals for the 2014 NEI v1 point sources were accepted through January 15, 2016. We then compared facility-level pollutant sums appearing in either the 2014 NEI S/L/T-submitted values or the 2011v2 NEI. The comparison included all facilities and pollutants, including any missing from the 2014 submittals (i.e., present in 2011 but not 2014) as well as any that were new in the 2014 submittals and all that were common to both years. We included additional columns to the comparison table to show the 2014 emission values from the 2014 Toxics Release Inventory (TRI) and the 2014 Clean Air Markets Division (CAMD) sulfur dioxide (SO_2) and nitrogen oxide (NOx) continuous emissions monitoring (CEM) data. We added columns that showed the percent differences between the 2014 S/L/T agency-submitted facility totals and each of these three comparison datasets. To create a more focused review and comparison table, we limited these results to include only cases where the 2014 S/L/T agency-submitted facility total was more than 50 percent different from the 2011 facility total and with an absolute mass value of the difference greater than a pollutant-specific threshold amount[2]. When a facility-pollutant combination was new in 2014 or appeared only in the 2011 NEI v2, we

[2] These thresholds are available on the 2014v1 Supplemental Data FTP site as file "2014_point_pollutant_thresholds_qa_flag1.xlsx"

included those values only when they exceeded the absolute mass values greater than the pollutant-specific thresholds because the percent differences were undefined. We provided[3] the resulting table of 4,428 records to S/L/T agencies for review.

State/local/tribal edits to address any emissions values were accepted in the Emissions Inventory System (EIS) until July 1, 2016. The S/L/T agencies did not change most of the highlighted values. Where the comparisons were exceptionally suspect, the EPA contacted the agencies by phone or by email if no edits had been made to obtain confirmation of the reported values. For a small number of cases, neither confirmation nor edits were obtained, and the value was tagged to be excluded from selection for the NEI. In some but not all of these instances, a value from TRI or the CAMD data sets was available as a replacement.

Similar to previous NEI years, we quality assured the latitude-longitude coordinates at both the site level and the release point level. In previous NEI cycles, we had reviewed, verified, and locked (in EIS) approximately 2,500 site-level coordinates of the most significant emitting facilities. For the 2014 NEI coordinate review, we compared all other site coordinate pairs to the county boundaries for the FIPS county codes reported for those facilities. We then identified all facilities that met the following criteria: (1) more than 50 tons total criteria pollutant emissions or more than 20 pounds total hazardous air pollutants (HAPs) for 2014, (2) the coordinates caused the location of the facility to be more than a half mile outside of its indicated county. For these facilities, we reviewed the location using Google Earth, edited the location as needed in EIS, and locked the location in EIS.

In addition, we compared the release point coordinates of all release points with any 2014 emissions to their site level coordinates, whether protected or not. In cases that we found a difference of more than 0.005 degrees (approximately 0.25 miles) in total latitude plus longitude, we reviewed the release point coordinates in Google Earth and edited as needed in EIS, and the *site-level* coordinates were then locked in EIS. This check was able to find two cases: (1) where the independently-reported release point coordinates may indicate either a suspect site-level coordinate, even if plotting within the correct county, or (2) an inaccurate release point coordinate. We also made a third quality assurance check to ensure that the coordinates for any release point that had emissions greater than 10 pounds for any key high-risk HAP that was within 0.005 degrees of a verified site coordinate. This check resulted in additional site coordinate reviews and protections. Finally, the site coordinates as found in the EPA's Facility Registry System were compared to those in EIS. Any facilities where these coordinates differed by more than 0.01 degrees and with greater than 50 tons criteria emissions or 500 pounds HAP emissions were reviewed, edited, and protected as needed.

We also attempted to find important cases of emissions being incorrectly reported as emitting at ground level through a fugitive release rather than through a stack. To do this, we reviewed emission processes with 2014 emissions data to identify instances where S/L/T agencies reported an apparent combustion sources over 50 tons of NOx as emitting through a fugitive release point. The largest such emission processes were individually reviewed to see if there was an existing stack release point with valid parameters in EIS that looked like it may have been the intended release point. Where such a possible match was found, the emissions process in the EIS facility inventory was adjusted to use that stack release point. Where no such stack release point existed within the facility, a new stack release point with a default height of 100 feet, diameter of 1 foot, velocity of 50 feet per second and a temperature of 300 degrees was created and used for the emission process. A total of 57 such new stacks were created under this step.

[3] We emailed the Emission Inventory System data submitters the table and instructions on February 27, 2016.

3.1.2 Sources of EPA data and selection hierarchy

Table 3-1 lists the datasets that we used to compile the 2014 NEI point inventory and the hierarchy used to choose which data value to use for the NEI when multiple data sets are available for the same emissions source (see Section 2.2 for more detail on the EIS selection process).

The EPA developed all datasets other than those containing S/L/T agency data and the dataset containing emissions from offshore oil and gas platforms in federal waters in the Gulf of Mexico. The primary purpose of the EPA datasets is to add or "gap fill" pollutants or sources not provided by S/L/T agencies, to resolve inconsistencies in S/L/T agency-reported pollutant submissions for particulate matter (PM) (Section 3.1.3) and to speciate S/L/T agency reported total chromium into hexavalent and trivalent forms (Section 3.1.4).

The hierarchy or "order" provided in the tables below defines which data are to be used for situations where multiple datasets provide emissions for the same pollutant and emissions process. The dataset with the lowest order on the list is preferentially used over other datasets. The table includes the rationale for why each dataset was assigned its position in the hierarchy. In addition to the order of the datasets, the selection also considers whether individual data values have been tagged (see Section 2.2.6). Any data that were tagged by the EPA in any of the datasets were not used. State/local/tribal agency data were tagged only if they were deemed to be likely outliers and were not addressed during the S/L/T agency data reviews. The 2014v1 point source selection also excluded greenhouse gases, dioxins and furans, and radionuclides. The EPA has not evaluated the completeness or accuracy of the S/L/T agency dioxin and furan values nor radionuclides, and does not have plans to supplement these reported emissions with other data sources to compile a complete estimate for dioxin and furans nor radionuclides as part of the NEI. The EPA's official inventory of greenhouse gases (GHGs) is compiled separately from the NEI criteria and hazardous air pollutant inventory and is available on the U.S. Greenhouse Gas Inventory Report website.

Table 3-1: Data sets and selection hierarchy used for 2014v1 NEI point source data category

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014EPA_PM-Aug	PM species added to gap fill missing S/L/T agency data or make corrections where S/L/T agency have inconsistent emissions across PM components. Uses ratios of emission factors from the PM Augmentation Tool for covered source classification codes (SCCs). For SCCs without emission factors in the tool, checks/corrects discrepancies or missing PM species using basic relationships such as ensuring that primary PM is greater than or equal to filterable PM (see Section 3.1.3). This dataset is ahead of the S/L/T agency data in order to correct the S/L/T agency values that had inconsistencies across PM components.	1
Responsible Agency Selection	S/L/T agency submitted data. These data are selected ahead of lower hierarchy datasets except where individual values in the S/L/T agency emissions were suspected outliers that were not addressed during the draft review and therefore tagged by the EPA.	2
2014EPA_EGU	HAP and CAP emissions from 3 sources: 1. Emissions factors (EFs) for lead (Pb), mercury (Hg), other HAP metals, acid gas HAP and PM emissions from the Mercury and Air Toxics (MATS) rule testing program for electric generating utilities(EGUs) along with 2014 CAMD heat input data 2. Annual sum of CAMD hourly CEM data for SO_2 and NOx 3. EFs used in previous year inventories from AP-42 and other sources along with 2014 CAMD heat input data.	3

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014EPA_Cr_Aug	Hexavalent and trivalent chromium speciated from S/L/T agency reported chromium. EIS augmentation function creates the dataset by applying multiplication factors by SCC, facility, process or North American Industry Classification System (NAICS) code to S/L/T agency total chromium. See Section 3.1.4.	4
2014EPA_Oth_CarryFwd	2011 emissions values for 212 facilities and 12 pollutants not reported in 2014 S/L/T datasets but appear to still be operating and were above CAP reporting thresholds in 2011. Includes Coke Oven Emissions adds for 5 facilities.	5
2014EPA_TRI	TRI data for the year 2014 (see Section 3.1.5). These data are selected for a facility only when the S/L/T agency data do not include emissions for a given pollutant at any process for that facility.	6
2014EPA_Airports	CAP and HAP emissions for aircraft operations including commercial, general aviation, air taxis and military aircraft, auxiliary power units and ground support equipment computed by the EPA for approximately 20,000 airports. Methods include the use of the Federal Aviation Administration's (FAA's) Emissions and Dispersion Modeling System (EDMS) (see Section 3.2).	7
2014EPA_Rail	CAP and HAP emissions for diesel rail yard locomotives. CAP emissions computed using yard-specific EFs, yard-specific fleet information, and using national fuel values that have been allocated to rail yards using an approximation of line haul activity within the yard. HAP emissions computed using HAP-to-CAP emission ratios (see Section 3.3).	8
2011EPA_LF	Landfill emissions developed by EPA using methane data from the EPA's GHG reporting rule program. The dataset contains only those landfills for which no pollutants were reported to EIS by the S/L/T agency in the 2014 reporting year.	9
2014EPA_HAPAug	HAP data computed from S/L/T agency criteria pollutant data using HAP/CAP EF ratios based on the EPA Factor Information Retrieval System (WebFIRE) database as described in Section 3.1.6. These data are selected below the TRI data and 2014EPA_Oth_CarryFwd because the TRI data are expected to be better. These data are selected for a facility only when not included in the S/L/T agency data.	10
2014EPA_HAP-Aug_PMaug	This dataset was created in the same fashion as the 2014EPA_HAPAug dataset above and is a supplement to it. This dataset contains HAPs calculated by applying a ratio to PM10-FIL emissions, for those instances where the S/L/T dataset did not contain any PM10-FIL emissions, but the PM augmentation routine was able to calculate a PM10-FIL value from some PM species that was reported by the S/L/T.	11
2014EPA_BOEM	2011 Gulfwide Emission Inventory CAP emissions from Offshore oil platforms located in Federal Waters in the Gulf of Mexico developed by the U.S. Department of the Interior, Bureau of Ocean and Energy Management (BOEM), Regulation, and Enforcement in the National Inventory Input Format and converted to the CERS format by the EPA. The state code for data from this data set is "DM" (Federal Waters). For the 2014v1 NEI, we used the 2011 BOEM data because the 2014 BOEM data was not available in time for 2014v1.	12

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014EPA_PMspecies	Adds speciated PM2.5 data to resulting selection. This is a result of offline emissions speciation where the resulting PM25-PRI selection emissions are split into the 5 PM species: elemental (black) carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). Also adds a copy of PM2.5-PRI and PM10-PRI from diesel engines, relabeled as DIESEL-PM pollutants.	13
2014_EPA_MOVES	This dataset was listed in the point source hierarchy in error. It does not contain any point source emissions values.	14

3.1.3 Particulate matter augmentation

Particulate matter emissions components[4] in the NEI are: primary PM10 (called PM10-PRI in the EIS and NEI) and primary PM2.5 (PM25-PRI), filterable PM10 (PM10-FIL) and filterable PM2.5 (PM25-FIL) and condensable PM (PM-CON, which is all within the PM2.5 portion on PM, i.e., PM25-PRI = PM25-FIL + PM-CON). The EPA needed to augment the S/L/T agency PM components to ensure completeness of the PM components in the final NEI and to ensure that S/L/T agency data did not contain inconsistencies. An example of an inconsistency is if the S/L/T agency submitted a primary PM2.5 value that was greater than a primary PM10 value for the same process. Commonly, the augmentation added condensable PM or PM filterable (PM10-FIL and/or PM25-FIL) where no value was provided, or primary PM2.5 where only primary PM10 was provided. Additional information on the procedure is provided in the 2008 NEI PM augmentation documentation [ref 1].

In general, emissions for PM species missing from S/L/T agency inventories were calculated by applying factors to the PM emissions data supplied by the S/L/T agencies. These conversion factors were first used in the 1999 NEI's "PM Calculator" as described in an NEI conference paper [ref 2]. The resulting methodology allows the EPA to derive missing PM10-FIL or PM25-FIL emissions from incomplete S/L/T agency submissions based on the SCC and PM controls that describe the emissions process. In cases where condensable emissions are not reported, conversion factors developed are applied to S/L/T agency reported PM species or species derived from the PM Calculator databases. The PM Calculator, has undergone several edits since 1999; now called the "PM Augmentation Tool," this Microsoft ® Access ® database is available on the PM Augmentation web site.

3.1.4 Chromium speciation

An overview of chromium speciation, as it impacts both the point and nonpoint data category, is discussed in Section 2.2.2.

The EIS generates and stores an EPA dataset containing the resultant hexavalent and trivalent chromium species. The EPA then used this dataset in the 2014 NEI selection by adding it to the selection hierarchy shown in Table 3-1, excluding the S/L/T agency total chromium from the selection through a pollutant exception to the hierarchy. This EIS feature does not speciate chromium from any of the EPA datasets because the EPA data contains only speciated chromium.

For the 2014 NEI, the EPA named this dataset "2014EPA_Cr_Aug." Most of the speciation factors used in the 2014 NEI are SCC-based and are the same as were used for the 2008 and 2011 NEIs. The factors are based on data that have long been used by the EPA for the National Air Toxics Assessment and other risk projects and are available on the 2014v1 Supplemental data FTP site.

[4] We use the term "components" here rather than "species" to avoid confusion with the PM2.5 "species" that are used for air quality modeling (e.g., organic carbon, elemental carbon, sulfate, nitrate, and other PM).

3.1.5 Use of the 2014 Toxics Release Inventory

The EPA used air emissions data from the 2014 TRI to supplement point source HAP and ammonia emissions provided to the EPA by S/L/T agencies. The resulting augmentation dataset is labeled as "2014EPA_TRI" in the Table 3-1 selection hierarchy shown above. For 2014, all TRI emissions values that could reasonably be matched to an EIS facility were loaded into the EIS for viewing and comparison if desired, but only those pollutants that were not reported anywhere at the EIS facility by the S/L/T agency were considered for inclusion in the 2014 NEI.

The basis of the 2014EPA_TRI dataset is the US EPA's 2011 Toxics Release Inventory (TRI) Program. The TRI is an EPA database containing data on disposal or other releases including air emissions of over 650 toxic chemicals from approximately 21,000 facilities. One of TRI's primary purposes is to inform communities about toxic chemical releases to the environment. Data are submitted annually by U.S. facilities that meet TRI reporting criteria. The TRI database used for this project was named TRI_2014_US.csv and was downloaded on February 10, 2016, from the TRI Basic Data Files: Calendar Years 1987 – 2016 web site.

The approach used for the 2014 NEI was the same as that used for the 2011 NEI. The TRI emissions were included in the EIS (and the NEI) as facility-total stack and facility-total fugitive emissions processes, which matches the aggregation detail of the TRI database. Double-counting of TRI and other data sources was prevented by tagging (and not using) any TRI pollutant emissions for a facility where the S/L/T agency or a higher priority (as per Table 3-1) EPA dataset also had a pollutant emissions value for any unit and process within that facility.

The following steps describe in more detail the development of the 2014EPA_TRI dataset.

1. **Update the TRI_ID to EIS_ID facility-level crosswalk**
   For the 2014 NEI, the same crosswalk list of TRI IDs that was used for the 2011 NEI was used as a starting point. A review of the 2014 TRI facilities was conducted to identify new facilities with significant emissions that had not been previously matched to an EIS facility. A total of approximately 150 additional TRI facilities were added to the crosswalk for 2014.
2. **Map TRI pollutant codes to valid EIS pollutant codes and sum where necessary**
   Table 3-2 provides the pollutant mapping from TRI pollutants to EIS pollutants. Many of the 650 TRI pollutants do not have any EIS counterpart, and so are not shown in Table 3-2. In addition, several EIS pollutants may be reported to TRI as either of two TRI pollutants. For example, both Pb and Pb compounds may be reported to TRI, and similarly for several other metal and metal compound TRI pollutants. Table 3-2 shows where such pairs of TRI pollutants both correspond to the same EIS pollutant. In such cases, we summed the two TRI pollutants together as part of the step of assigning the TRI emissions to valid EIS pollutant codes. For the 2014 NEI, a total of 184 TRI pollutant codes were mapped to 172 unique EIS pollutant codes. Similar to the 2011 NEI, we did not use TRI emissions reported for TRI pollutants: "Certain Glycol Ethers," "Dioxin and Dioxin-like Compounds," Dichlorobenzene (mixed isomers)," and "Toluene di-isocyanate (mixed isomers)," because they do not represent the same scope as the EIS pollutants: "Glycol ethers," "Dioxins/Furans as 2,3,7,8-TCDD TEQs," "1,4-Dichlorobenzene," and "2,4-Di-isocyanate," respectively. We maintained TRI stack and fugitive emissions separately during the summation step and maintained that separation through the storage of the TRI emissions in the EIS.

Table 3-2: Mapping of TRI pollutant codes to EIS pollutant codes

TRI CAS	TRI Pollutant Name	EIS Pollutant Code	EIS Pollutant Name
79345	1,1,2,2-TETRACHLOROETHANE	79345	1,1,2,2-TETRACHLOROETHANE
79005	1,1,2-TRICHLOROETHANE	79005	1,1,2-TRICHLOROETHANE
57147	1,1-DIMETHYL HYDRAZINE	57147	1,1-DIMETHYL HYDRAZINE
120821	1,2,4-TRICHLOROBENZENE	120821	1,2,4-TRICHLOROBENZENE
96128	1,2-DIBROMO-3-CHLOROPROPANE	96128	1,2-DIBROMO-3-CHLOROPROPANE
57147	1,1-DIMETHYL HYDRAZINE	57147	1,1-Dimethyl Hydrazine
106887	1,2-BUTYLENE OXIDE	106887	1,2-EPOXYBUTANE
75558	PROPYLENEIMINE	75558	1,2-PROPYLENIMINE
106990	1,3-BUTADIENE	106990	1,3-BUTADIENE
542756	1,3-DICHLOROPROPYLENE	542756	1,3-DICHLOROPROPENE
1120714	PROPANE SULTONE	1120714	1,3-PROPANESULTONE
106467	1,4-DICHLOROBENZENE	106467	1,4-DICHLOROBENZENE
25321226	DICHLOROBENZENE (MIXED ISOMERS)		NA- pollutant not used
95954	2,4,5-TRICHLOROPHENOL	95954	2,4,5-TRICHLOROPHENOL
88062	2,4,6-TRICHLOROPHENOL	88062	2,4,6-TRICHLOROPHENOL
94757	2,4-DICHLOROPHENOXY ACETIC ACID	94757	2,4-DICHLOROPHENOXY ACETIC ACID
51285	2,4-DINITROPHENOL	51285	2,4-DINITROPHENOL
121142	2,4-DINITROTOLUENE	121142	2,4-DINITROTOLUENE
53963	2-ACETYLAMINOFLUORENE	53963	2-ACETYLAMINOFLUORENE
79469	2-NITROPROPANE	79469	2-NITROPROPANE
91941	3,3'-DICHLOROBENZIDINE	91941	3,3'-Dichlorobenzidine
119904	3,3'-DIMETHOXYBENZIDINE	119904	3,3'-Dimethoxybenzidine
119937	3,3’-DIMETHYLBENZIDINE	119937	3,3’-DIMETHYLBENZIDINE
101144	4,4’-METHYLENEBIS(2-CHLOROANILINE)	101144	4,4’-METHYLENEBIS(2-CHLORANILINE)
101779	4,4’-METHYLENEDIANILINE	101779	4,4’-METHYLENEDIANILINE
534521	4,6-DINITRO-O-CRESOL	534521	4,6-DINITRO-O-CRESOL
92671	4-AMINOBIPHENYL	92671	4-AMINOBIPHENYL
60117	4-DIMETHYLAMINOAZOBENZENE	60117	4-DIMETHYLAMINOAZOBENZENE
100027	4-NITROPHENOL	100027	4-NITROPHENOL
75070	ACETALDEHYDE	75070	ACETALDEHYDE
60355	ACETAMIDE	60355	ACETAMIDE
75058	ACETONITRILE	75058	ACETONITRILE
98862	ACETOPHENONE	98862	ACETOPHENONE
107028	ACROLEIN	107028	ACROLEIN
79061	ACRYLAMIDE	79061	ACRYLAMIDE
79107	ACRYLIC ACID	79107	ACRYLIC ACID
107131	ACRYLONITRILE	107131	ACRYLONITRILE
107051	ALLYL CHLORIDE	107051	ALLYL CHLORIDE
7664417	AMMONIA	NH3	Ammonia
62533	ANILINE	62533	ANILINE
7440360	ANTIMONY	7440360	ANTIMONY
N010	ANTIMONY COMPOUNDS	7440360	ANTIMONY
7440382	ARSENIC	7440382	ARSENIC
N020	ARSENIC COMPOUNDS	7440382	ARSENIC
1332214	ASBESTOS (FRIABLE)	1332214	ASBESTOS
71432	BENZENE	71432	BENZENE
92875	BENZIDINE	92875	BENZIDINE
98077	BENZOIC TRICHLORIDE	98077	BENZOTRICHLORIDE
100447	BENZYL CHLORIDE	100447	BENZYL CHLORIDE
7440417	BERYLLIUM	7440417	BERYLLIUM
N050	BERYLLIUM COMPOUNDS	7440417	BERYLLIUM
92524	BIPHENYL	92524	BIPHENYL
117817	DI(2-ETHYLHEXYL) PHTHALATE	117817	BIS(2-ETHYLHEXYL)PHTHALATE
542881	BIS(CHLOROMETHYL) ETHER	542881	Bis(Chloromethyl)Ether
75252	BROMOFORM	75252	BROMOFORM
7440439	CADMIUM	7440439	CADMIUM
N078	CADMIUM COMPOUNDS	7440439	CADMIUM
156627	CALCIUM CYANAMIDE	156627	CALCIUM CYANAMIDE
133062	CAPTAN	133062	CAPTAN
63252	CARBARYL	63252	CARBARYL
75150	CARBON DISULFIDE	75150	CARBON DISULFIDE

TRI CAS	TRI Pollutant Name	EIS Pollutant Code	EIS Pollutant Name
56235	CARBON TETRACHLORIDE	56235	CARBON TETRACHLORIDE
463581	CARBONYL SULFIDE	463581	CARBONYL SULFIDE
120809	CATECHOL	120809	CATECHOL
57749	CHLORDANE	57749	CHLORDANE
7782505	CHLORINE	7782505	CHLORINE
79118	CHLOROACETIC ACID	79118	CHLOROACETIC ACID
108907	CHLOROBENZENE	108907	CHLOROBENZENE
510156	CHLOROBENZILATE	510156	Chlorobenzilate
67663	CHLOROFORM	67663	CHLOROFORM
107302	CHLOROMETHYL METHYL ETHER	107302	CHLOROMETHYL METHYL ETHER
126998	CHLOROPRENE	126998	CHLOROPRENE
7440473	CHROMIUM	7440473	CHROMIUM
N090	CHROMIUM COMPOUNDS (EXCEPT CHROMITE ORE MINED IN THE TRANSVAAL REGION)	7440473	CHROMIUM
7440484	COBALT	7440484	COBALT
N096	COBALT COMPOUNDS	7440484	COBALT
1319773	CRESOL (MIXED ISOMERS)	1319773	CRESOL/CRESYLIC ACID (MIXED ISOMERS)
108394	M-CRESOL	108394	M-CRESOL
95487	O-CRESOL	95487	O-CRESOL
106445	P-CRESOL	106445	P-CRESOL
98828	CUMENE	98828	CUMENE
N106	CYANIDE COMPOUNDS	57125	CYANIDE
74908	HYDROGEN CYANIDE	57125	Cyanide
132649	DIBENZOFURAN	132649	DIBENZOFURAN
84742	DIBUTYL PHTHALATE	84742	DIBUTYL PHTHALATE
111444	BIS(2-CHLOROETHYL) ETHER	111444	DICHLOROETHYL ETHER
62737	DICHLORVOS	62737	DICHLORVOS
111422	DIETHANOLAMINE	111422	DIETHANOLAMINE
64675	DIETHYL SULFATE	64675	DIETHYL SULFATE
131113	DIMETHYL PHTHALATE	131113	DIMETHYL PHTHALATE
77781	DIMETHYL SULFATE	77781	DIMETHYL SULFATE
79447	DIMETHYLCARBAMYL CHLORIDE	79447	DIMETHYLCARBAMOYL CHLORIDE
N120	DIISOCYANATES		NA- pollutant not used
26471625	TOLUENE DIISOCYANATE (MIXED ISOMERS)		NA- pollutant not used
584849	TOLUENE-2,4-DIISOCYANATE	584849	2,4-Toluene Diisocyanate
N150	DIOXIN AND DIOXIN-LIKE COMPOUNDS		NA- pollutant not used
106898	EPICHLOROHYDRIN	106898	EPICHLOROHYDRIN
140885	ETHYL ACRYLATE	140885	ETHYL ACRYLATE
51796	URETHANE	51796	ETHYL CARBAMATE
75003	CHLOROETHANE	75003	ETHYL CHLORIDE
100414	ETHYLBENZENE	100414	ETHYL BENZENE
106934	1,2-DIBROMOETHANE	106934	ETHYLENE DIBROMIDE
107062	1,2-DICHLOROETHANE	107062	ETHYLENE DICHLORIDE
107211	ETHYLENE GLYCOL	107211	ETHYLENE GLYCOL
151564	ETHYLENEIMINE	151564	Ethyleneimine
75218	ETHYLENE OXIDE	75218	ETHYLENE OXIDE
96457	ETHYLENE THIOUREA	96457	ETHYLENE THIOUREA
75343	ETHYLIDENE DICHLORIDE	75343	ETHYLIDENE DICHLORIDE
50000	FORMALDEHYDE	50000	FORMALDEHYDE
N230	CERTAIN GLYCOL ETHERS	171	N/A Pollutant not used
76448	HEPTACHLOR	76448	HEPTACHLOR
118741	HEXACHLOROBENZENE	118741	HEXACHLOROBENZENE
87683	HEXACHLORO-1,3-BUTADIENE	87683	HEXACHLOROBUTADIENE
77474	HEXACHLOROCYCLOPENTADIENE	77474	HEXACHLOROCYCLOPENTADIENE
67721	HEXACHLOROETHANE	67721	HEXACHLOROETHANE
110543	N-HEXANE	110543	HEXANE
302012	HYDRAZINE	302012	HYDRAZINE
7647010	HYDROCHLORIC ACID (1995 AND AFTER “ACID AEROSOLS” ONLY)	7647010	HYDROCHLORIC ACID
7664393	HYDROGEN FLUORIDE	7664393	HYDROGEN FLUORIDE
123319	HYDROQUINONE	123319	HYDROQUINONE
7439921	LEAD	7439921	LEAD

TRI CAS	TRI Pollutant Name	EIS Pollutant Code	EIS Pollutant Name
N420	LEAD COMPOUNDS	7439921	LEAD
58899	LINDANE	58899	1,2,3,4,5,6-HEXACHLOROCYCLOHEXANE
108316	MALEIC ANHYDRIDE	108316	MALEIC ANHYDRIDE
7439965	MANGANESE	7439965	MANGANESE
N450	MANGANESE COMPOUNDS	7439965	MANGANESE
7439976	MERCURY	7439976	MERCURY
N458	MERCURY COMPOUNDS	7439976	MERCURY
67561	METHANOL	67561	METHANOL
72435	METHOXYCHLOR	72435	METHOXYCHLOR
74839	BROMOMETHANE	74839	METHYL BROMIDE
74873	CHLOROMETHANE	74873	METHYL CHLORIDE
71556	1,1,1-TRICHLOROETHANE	71556	METHYL CHLOROFORM
74884	METHYL IODIDE	74884	METHYL IODIDE
108101	METHYL ISOBUTYL KETONE	108101	METHYL ISOBUTYL KETONE
624839	METHYL ISOCYANATE	624839	METHYL ISOCYANATE
80626	METHYL METHACRYLATE	80626	METHYL METHACRYLATE
1634044	METHYL TERT-BUTYL ETHER	1634044	METHYL TERT-BUTYL ETHER
75092	DICHLOROMETHANE	75092	METHYLENE CHLORIDE
60344	METHYL HYDRAZINE	60344	METHYLHYDRAZINE
121697	N,N-DIMETHYLANILINE	121697	N,N-DIMETHYLANILINE
68122	N,N-DIMETHYLFORMAMIDE	68122	N,N-DIMETHYLFORMAMIDE
91203	NAPHTHALENE	91203	NAPHTHALENE
7440020	NICKEL	7440020	NICKEL
N495	NICKEL COMPOUNDS	7440020	NICKEL
98953	NITROBENZENE	98953	NITROBENZENE
684935	N-NITROSO-N-METHYLUREA	684935	N-Nitroso-N-Methylurea
90040	O-ANISIDINE	90040	O-ANISIDINE
95534	O-TOLUIDINE	95534	O-TOLUIDINE
123911	1,4-DIOXANE	123911	P-DIOXANE
56382	PARATHION	56382	Parathion
82688	QUINTOZENE	82688	PENTACHLORONITROBENZENE
87865	PENTACHLOROPHENOL	87865	PENTACHLOROPHENOL
108952	PHENOL	108952	PHENOL
75445	PHOSGENE	75445	PHOSGENE
7803512	PHOSPHINE	7803512	PHOSPHINE
7723140	PHOSPHORUS (YELLOW OR WHITE)	7723140	PHOSPHORUS
85449	PHTHALIC ANHYDRIDE	85449	PHTHALIC ANHYDRIDE
1336363	POLYCHLORINATED BIPHENYLS	1336363	POLYCHLORINATED BIPHENYLS
120127	ANTHRACENE	120127	Anthracene
191242	BENZO(G,H,I)PERYLENE	191242	BENZO[G,H,I,]PERYLENE
85018	PHENANTHRENE	85018	PHENANTHRENE
N590	POLYCYCLIC AROMATIC COMPOUNDS	130498292	PAH, total
106503	P-PHENYLENEDIAMINE	106503	P-PHENYLENEDIAMINE
123386	PROPIONALDEHYDE	123386	PROPIONALDEHYDE
114261	PROPOXUR	114261	PROPOXUR
78875	1,2-DICHLOROPROPANE	78875	PROPYLENE DICHLORIDE
75569	PROPYLENE OXIDE	75569	PROPYLENE OXIDE
91225	QUINOLINE	91225	QUINOLINE
106514	QUINONE	106514	QUINONE
7782492	SELENIUM	7782492	SELENIUM
N725	SELENIUM COMPOUNDS	7782492	SELENIUM
100425	STYRENE	100425	STYRENE
96093	STYRENE OXIDE	96093	STYRENE OXIDE
127184	TETRACHLOROETHYLENE	127184	TETRACHLOROETHYLENE
7550450	TITANIUM TETRACHLORIDE	7550450	TITANIUM TETRACHLORIDE
108883	TOLUENE	108883	TOLUENE
95807	2,4-DIAMINOTOLUENE	95807	TOLUENE-2,4-DIAMINE
8001352	TOXAPHENE	8001352	TOXAPHENE
79016	TRICHLOROETHYLENE	79016	TRICHLOROETHYLENE
121448	TRIETHYLAMINE	121448	TRIETHYLAMINE
1582098	TRIFLURALIN	1582098	TRIFLURALIN
108054	VINYL ACETATE	108054	VINYL ACETATE

TRI CAS	TRI Pollutant Name	EIS Pollutant Code	EIS Pollutant Name
75014	VINYL CHLORIDE	75014	VINYL CHLORIDE
75354	VINYLIDENE CHLORIDE	75354	VINYLIDENE CHLORIDE
108383	M-XYLENE	108383	M-XYLENE
95476	O-XYLENE	95476	O-XYLENE
106423	P-XYLENE	106423	P-XYLENE
1330207	XYLENE (MIXED ISOMERS)	1330207	XYLENES (MIXED ISOMERS)

3. **Split TRI total chromium emissions into hexavalent and trivalent emissions**
The TRI allows facilities to report either "Chromium" or "Chromium compounds," but not the hexavalent or trivalent chromium species that are needed for the NEI (see Section 3.1.3). Because the only characterization available for the TRI facilities or their emissions is the facilities' NAICS codes, we created a NAICS-based set of fractions to split the TRI-reported total chromium emissions into the hexavalent and trivalent chromium species. A table of Standard Industrial Classification (SIC)-based chromium split fractions was available from earlier year NEI usage of TRI databases, which had been compiled by SIC rather than NAICS. The earlier SIC-based fractions were used wherever they could be re-assigned to a closely matching NAICS description.

Unfortunately, not all SIC-based fractions could be assigned this way, so we computed NAICS-based split fractions for any NAICS codes in the 2014 TRI data that did not already have an SIC-to-NAICS assigned split fraction. These factors were used for the remaining TRI-reported chromium. To calculate the NAICS-based factors, we summed by NAICS the total amounts of chromium III and chromium VI for the entire U.S. in the 2014 draft NEI data. These 2014 NEI S/L/T emissions were either reported directly by the S/L/T agencies as chromium III and chromium VI, or they had been split from S/L/T agency-reported total chromium by the EPA using the procedures described in Section 3.1.4. Those procedures largely rely on either SCC-based or Regulatory code-based split factors. The derived NAICS split factors, therefore, represent a weighted average of the SCC and Regulatory code-based split factors, weighted according to the mass of each chromium valence in the 2014 draft NEI for that NAICS.

After all TRI facilities with chromium had been assigned a NAICS-based split factor, the factors were applied separately to both the TRI stack and fugitive total chromium emissions. This resulted in speciated chromium emissions for each facility's stack and fugitive emissions that were included in the EIS as part of the 2014EPA_TRI dataset.

4. **Review high TRI emissions values for and exclude any data suspected to be outliers**
A review and comparison of the largest TRI emissions values was conducted for several key high-risk pollutants. The following pollutants were specifically reviewed, although a few extremely large values for some of the other TRI pollutants were also noticed and treated in the same manner: Hg, Pb, chromium, manganese, nickel, arsenic, 1,3 butadiene, benzene, toluene, ethyl benzene, p-xylene, methanol, acrolein, carbon tetrachloride, tetrachloroethylene, methylene chloride, acrylonitrile, 1,4-dichlorobenzene, ethylene oxide, hydrochloric acid, hydrogen fluoride, chlorine, 2,4-toluene diisocyanate, hexamethylene diisocyanate, and naphthalene. The review included looking at the largest 10 emitting facilities for each of the pollutants in the 2014 TRI dataset itself to identify large differences between facilities and unexpected industry types. Comparisons were then made to the 2011 TRI and the 2014 draft NEI emissions values from S/L/T agencies for any suspect facilities identified by that review (as described above in Section 3.1.1).

5. **Write the 2014 TRI emissions to EIS Process IDs with stack and fugitive release points**
The total facility stack and total facility fugitive emissions values from the above steps were written to a set of EIS process IDs created to reflect those facility total type emissions. In most cases, the EIS process IDs for a given facility already existed in EIS as a result of the 2002 and 2005 NEI inventories which were used to populate the original EIS data system. Those NEI years contained the TRI stack and fugitive totals as single processes. Where such legacy NEI process IDs did not exist in the EIS, they were created.

6. **Revise SCCs on the EIS Processes used for the TRI emissions**
The 2002 and 2005 NEIs had assigned all the TRI emissions to a default process code SCC of 39999999, which caused a large amount of HAP emissions to be summed to a misleading "miscellaneous" sector. The 2008 NEI approach reduced this problem somewhat because it apportioned all TRI emissions to the multiple processes and SCCs that were used by the S/L/T agencies to report their emissions, but this apportioning created other distortions. The 2011 NEI reverted back to loading the TRI emissions as the single process stack and fugitive values as reported by facilities to the TRI, but we revised the SCCs on those single processes to something other than the default 39999999 wherever possible. The purpose of this is to allow the TRI emissions to map to a more appropriate EIS sector. For the 2014 NEI, we retained the 2011 approach, process IDs, and SCCs.

   To assign a SCC, we first determined for each facility and release type (stack or fugitive) which EIS Sector had the largest amount of S/L/T agency-reported emissions in the 2011 draft NEI. Within the largest EIS sector for the facility and release type, we then determined which single SCC had the largest emissions. The emissions values used were sums of emissions across all pollutants except carbon monoxide (CO), carbon dioxide (CO_2), and NO_X, with all units converted to tons. Excluding CO and CO_2 was done because their high mass would overwhelm the contribution of the other criteria pollutants, and NO_X was excluded because the HAPs that we are trying to assign to an appropriate summation sector are more closely associated with SO_2 or PM emissions. The usage of the default 39999999 SCC has not been completely eliminated as a result of this approach, because there remain a number of S/L/T agency-reported criteria emissions for some facilities in EIS for which that is the most viable SCC choice. In the rare cases that the S/L/T agency used 39999999 for the majority of their emissions, this SCC assignment approach did not work.

7. **Tag TRI pollutant emissions in EIS to avoid double counting with other datasets**
Because the 2014 NEI does not attempt to place the TRI emissions at the same processes used by the S/L/T agency datasets or other EPA datasets that are higher in the EIS selection hierarchy, it is necessary to tag any TRI emissions values stored in the EIS wherever the same pollutant is already reported by a S/L/T agency or one of the more preferred EPA datasets for a given EIS facility. In addition to a direct comparison of individually matching pollutants between these datasets, it is also necessary to compare to any of the related EIS pollutant codes that are in the same pollutant group.

   Table 3-3 shows the EIS pollutant groups that had to be accounted for in this comparison. For example, if the S/L/T agency data or the 2014EPA_EGU dataset included "Xylenes (Mixed Isomers)" for a facility, any of the related individual xylene isomers would be tagged in the 2014EPA_TRI dataset in the EIS as well as any "Xylenes (Mixed Isomers)." Tagging an emissions value in the EIS in any dataset makes that emissions value not available for selection to the NEI.

Table 3-3: Pollutant groups

Group Name	Pollutant Code	Pollutant
Chromium	7440473	Chromium
	1333820	Chromium Trioxide
	7738945	Chromic Acid (VI)
	18540299	Chromium (VI)
	16065831	Chromium III
Xylenes (Mixed Isomers)	1330207	Xylenes (Mixed Isomers)
	95476	o-Xylene
	106423	p-Xylene
	108383	m-Xylene
Cresol/Cresylic Acid (Mixed Isomers)	1319773	Cresol/Cresylic Acid (Mixed Isomers)
	95487	o-Cresol
	108394	m-Cresol
	106445	p-Cresol
Polychlorinated Biphenyls	1336363	Polychlorinated Biphenyls (PCBs)
	2050682	4,4’-Dichlorobiphenyl (PCB-15)
	2051243	Decachlorobiphenyl (PCB-209)
	2051607	2-Chlorobiphenyl (PCB-1)
	25429292	Pentachlorobiphenyl
	26601649	Hexachlorobiphenyl
	26914330	Tetrachlorobiphenyl
	28655712	Heptachlorobiphenyl
	53742077	Nonachlorobiphenyl
	55722264	Octachlorobiphenyl
	7012375	2,4,4’-Trichlorobiphenyl (PCB-28)
Polycyclic Organic Matter (POM)	130498292	PAH, total
	120127	Anthracene
	129000	Pyrene
	189559	Dibenzo[a,i]Pyrene
	189640	Dibenzo[a,h]Pyrene
	191242	Benzo[g,h,I,]Perylene
	191300	Dibenzo[a,l]Pyrene
	192654	Dibenzo[a,e]Pyrene
	192972	Benzo[e]Pyrene
	193395	Indeno[1,2,3-c,d]Pyrene
	194592	7H-Dibenzo[c,g]carbazole
	195197	BenzoIphenanthrene
	198550	Perylene
	203123	Benzo(g,h,i)Fluoranthene
	203338	Benzo(a)Fluoranthene
	205823	Benzo[j]fluoranthene
	205992	Benzo[b]Fluoranthene
	206440	Fluoranthene
	207089	Benzo[k]Fluoranthene
	208968	Acenaphthylene
	218019	Chrysene
	224420	Dibenzo[a,j]Acridine

Group Name	Pollutant Code	Pollutant
	226368	Dibenz[a,h]acridine
	2381217	1-Methylpyrene
	2422799	12-Methylbenz(a)Anthracene
	250	PAH/POM – Unspecified
	26914181	Methylanthracene
	3697243	5-Methylchrysene
	41637905	Methylchrysene
	42397648	1,6-Dinitropyrene
	42397659	1,8-Dinitropyrene
	50328	Benzo[a]Pyrene
	53703	Dibenzo[a,h]Anthracene
	5522430	1-Nitropyrene
	56495	3-Methylcholanthrene
	56553	Benz[a]Anthracene
	56832736	Benzofluoranthenes
	57835924	4-Nitropyrene
	57976	7,12-Dimethylbenz[a]Anthracene
	602879	5-Nitroacenaphthene
	607578	2-Nitrofluorene
	65357699	Methylbenzopyrene
	7496028	6-Nitrochrysene
	779022	9-Methyl Anthracene
	8007452	Coal Tar
	832699	1-Methylphenanthrene
	83329	Acenaphthene
	85018	Phenanthrene
	86737	Fluorene
	86748	Carbazole
	90120	1-Methylnaphthalene
	91576	2-Methylnaphthalene
	91587	2-Chloronaphthalene
Cyanide & Compounds	57125	Cyanide
	74908	Hydrogen Cyanide
Nickel & Compounds	7440020	Nickel
	12035722	Nickel Subsulfide
	1313991	Nickel Oxide
	604	Nickel Refinery Dust

3.1.6 HAP augmentation based on emission factor ratios

The 2014EPA_HAP-augmentation dataset was used for gap filling missing HAPs in the S/L/T agency-reported data. These missing HAPs are determined by comparing the "Expected Pollutant List for Point SCCs" with those that S/L/T agencies submitted. We calculated HAP emissions by multiplying the appropriate surrogate CAP emissions (provided by S/L/T agencies) by an emissions ratio of HAP to CAP EFs. For point sources, these EF ratios were largely the same as were used in the 2008 NEI v3, though additional quality assurance resulted in some changes. The ratios were computed using the EFs from WebFIRE and are based solely on the SCC code.

The computation of these point HAP to CAP ratios is described in detail in the 2008 NEI documentation, Section 3.1.5.

For pollutants other than Hg, we computed ratios for only the SCCs in WebFIRE that met specific criteria: 1) the CAP and HAP WebFIRE EFs were both based on uncontrolled emissions and, 2) the units of the EF had to be the same or be able to be converted to the same units. In addition, for Hg, we added ratios for point SCCs that were not in WebFIRE for both PM10-FIL (the CAP surrogate for Hg) and Hg by using Hg or PM10-FIL factors for similar SCCs and computing the resulting ratio. That process is described (and supporting data files provided) in the 2008 NEI documentation (Section 3.1.5.2), since these additional Hg augmentation factors were used in the 2008 NEI v3 as well.

A HAP augmentation feature was built into the EIS for the 2011 cycle, and the HAP EF ratios are available to the EIS users through the reference data link "Augmentation Priority Order." The same tables ("Priority Data" and "Priority Data Area") provide both the HAP augmentation factors and chromium speciation factors. The "Priority Data" table provides chromium speciation and HAP augmentation factors for point sources; the "Priority Data Area" table provides them for nonpoint sources. These tables provide the SCC, CAP surrogate, HAP and multiplication factor (HAP to CAP ratio). For access by non-EIS users, the zip file called "2014HAPAugFactors.zip" provides the emission ratios used for point and nonpoint data categories.

A key facet of our approach is that the resulting HAP augmentation dataset does duplicate HAPs from the S/L/T agency data or other EPA datasets. The extra step of data tagging of the HAP augmentation dataset was taken to ensure the NEI would not use the data from the HAP augmentation dataset for facilities where the HAP was reported by an S/L/T agency at any process at the facility or where the HAP was included in the EPA TRI dataset. For example, if a facility reported formaldehyde at process A only, and the WebFIRE emission factor database yields formaldehyde emissions for processes A, B, and C, then we would not use any records from the HAP augmentation dataset containing formaldehyde from any processes at the facility. If that facility had no formaldehyde, but the TRI dataset had formaldehyde for any processes at that facility, then the NEI would still not use formaldehyde from the HAP augmentation dataset for any of the processes (it would use the TRI data). If the EPA EGU dataset contained formaldehyde for that facility, we would use the HAP augmentation set but not for any process at the same unit as EPA EGU dataset. If the EPA EGU dataset contained formaldehyde at process A or any other process within the same unit as process A, then the HAP augmentation dataset would be used for processes B and C, but not process A.

This approach was taken to be conservative in our attempt to prevent double counted emissions, which is necessary because we know that some states aggregate their HAP emissions and assign to fewer or different processes than their CAP emissions. These types of differences are expected since CAPs are required to be submitted at the process level, but HAPs are entirely voluntary for the NEI's reporting rule. We used the EIS tagging to tag records from the 2014EPA_HAP-augmentation dataset to prevent double counting. Because some HAPs are in pollutant groups, if any one HAP in that group was reported by the state anywhere at the facility, then we tagged all HAPs in that group. We used the same groups as provided in Table 3-3.

We also tagged all point source HAP augmentation values where the HAP augmentation value exceeded the maximum emissions reported by any S/L/T agency for the same SCC/pollutant combination, or if no S/L/T agency reported any values for the same SCC/pollutant. This occurred a total of 9607 times.

3.2 Airports: aircraft-related emissions: updated in 2014v2

The EPA estimated emissions related to aircraft activity for all known U.S. airports, including seaplane ports and heliports, in the 50 states, Puerto Rico, and U.S. Virgin Islands. All of the approximately 20,000 individual airports are geographically located by latitude/longitude and stored in the NEI as point sources. As part of the development process, S/L/T agencies had the opportunity to provide both activity data as well emissions to the NEI. When activity data were provided, the EPA used that data to calculate the EPA's emissions estimates.

3.2.1 Sector Description

The aircraft sector includes all aircraft types used for public, private, and military purposes. This includes four types of aircraft: (1) commercial, (2) air taxis (AT), (3) general aviation (GA), and (4) military. A critical detail about the aircraft is whether each aircraft is turbine- or piston-driven, which allows the emissions estimation model to assign the fuel used, jet fuel or aviation gas, respectively. The fraction of turbine- and piston-driven aircraft is either collected or assumed for all aircraft types.

Commercial aircraft include those used for transporting passengers, freight, or both. Commercial aircraft tend to be larger aircraft powered with jet engines. Air taxis carry passengers, freight, or both, but usually are smaller aircraft and operate on a more limited basis than the commercial aircraft. General aviation includes most other aircraft used for recreational flying and personal transportation. Finally, military aircraft are associated with military purposes, and they sometimes have activity at non-military airports.

The national AT and GA fleets include both jet- and piston-powered aircraft. Most of the AT and GA fleets are made up of larger piston-powered aircraft, though smaller business jets can also be found in these categories. Military aircraft cover a wide range of aircraft types such as training aircraft, fighter jets, helicopters, and jet- and piston-powered planes of varying sizes.

The NEI also includes emission estimates for aircraft auxiliary power units (APUs) and aircraft ground support equipment (GSE) typically found at airports, such as aircraft refueling vehicles, baggage handling vehicles and equipment, aircraft towing vehicles, and passenger buses. These APUs and GSE are located at the airport facilities as point sources along with the aircraft exhaust emissions.

3.2.2 Sources aircraft emissions estimates

Aircraft exhaust, GSE, and APU emissions estimates are associated with aircrafts' landing and takeoff (LTO) cycle. LTO data were available from both S/L/T agencies and FAA databases. For airports where the available LTO included detailed aircraft-specific make and model information (e.g., Boeing 747-200 series), we used the FAA's EDMS to estimate emissions. For airports where FAA databases do not include such detail, the EPA used assumptions regarding the percent of these LTOs that were associated with piston-driven (using aviation gas) versus turbine-driven (using jet fuel) aircraft. Then, the EPA estimated emissions based on the percent of each aircraft type, LTOs, and EFs. Then, the EPA estimates emissions based on the percent of each aircraft type, LTOs, and EFs. Emissions factors for 'generic' aircraft, those without the make/model detail are available in the "nei20145_genericef_table.pdf" file on the [2014v2 Supplemental Data FTP site](). State agencies listed in Table 3-4 provided at least some component of aircraft-related emissions to the NEI.

In addition to airport facility point, the EPA also estimated in-flight Pb (from aviation gas) emissions that are allocated to counties in the nonpoint inventory. Details about EPA's estimates can be found in the "neiair2014_fin.pdf" file, also on the [2014v2 Supplemental Data FTP site]().

Table 3-4: Agencies that submitted aircraft-related emissions for 2014v1, except as noted

Agency	Summary	Notes
Delaware Department of Natural Resources and Environmental Control	Dover Air Force base submitted for 2014v2	

Agency	Summary	Notes
Georgia Department of Natural Resources	Unpaved airstrip (nonpoint) in 2 counties. Hartsfield airport submitted for 2014v2.	
Illinois Environmental Protection Agency	737 airports' emissions	
Tennessee Department of Environmental Conservation	Military aircraft emissions at one facility	
Texas Commission on Environmental Quality	2005 airports' emissions	EPA o- and m-xylene tagged to avoid double count with TX's 'mixed xylene' records
Utah Division of Air Quality	Military aircraft emissions at one facility	

3.3 Rail yard-related emissions: updated in 2014v2

See Section 4.20 for details on the emission estimation for rail line segment emissions which are stored in the nonpoint sector. The 2014v2 NEI includes non-zero emissions estimates for 955 rail yards. These emissions are associated with the operation of switcher engines at each yard.

3.3.1 Sector Description

The locomotive sector includes railroad locomotives powered by diesel-electric engines. A diesel-electric locomotive uses 2-stroke or 4-stroke diesel engines and an alternator or a generator to produce the electricity required to power its traction motors.

3.3.2 Sources rail yard emissions estimates

Rail yard estimates were compiled by the Eastern Regional Technical Advisory Committee's (ERTAC) rail group. The group coordinated with the Federal Rail Administration to rail yard switcher activity data and apply the equipment-specific emission factors appropriate. Their report on this work is available in the "Railv2_3ERTAC_Rail_2014_Inventory_Documentation_20170220.pdf" file on the 2014v2 Supplemental Data FTP site.

Rail yard point emissions are limited to one SCC (28500201). For 2014, the following agencies submitted rail yards: Illinois, Maryland, Minnesota, New Jersey and Texas. These submitted data were compared to EPA estimates. Where necessary, the EPA values were tagged to prohibit double counting. Nonpoint rail yard submittals were allowed and were also checked for double counting with point.

3.4 EGUs

The EPA developed a single combined dataset of emission estimates for EGUs to be used to fill gaps for pollutants and emission units not reported by S/L/T agencies. For the 2014EPA_EGU dataset, the emissions were estimated at the unit level, because that is the level at which the CAMD heat input activity data and the MATS-based emissions factors and the CAMD CEM data are available. The 2014EPA_EGU dataset was developed from three separate estimation sources. The three sources were the 2010 MATS rule development testing program EFs for 15 HAPs; annual sums of SO_2 and NO_x emissions based on the hourly CEM emissions reported to the EPA's CAMD's database; and heat-input based EFs that were built from AP-42 EFs and fuel heat and sulfur contents as part of the 2008 NEI development effort. We used the 2014 annual throughputs in BTUs from the CAMD database with the two EF sets to derive annual emissions for 2014. A small number of the AP-42-based estimates were discarded because the fuels or control configurations were found to be different than what they were during the 2008 development effort that provided the heat-input based EFs that were available.

As shown above in Table 3-1, the selection hierarchy was set such that S/L/T-submitted data was used ahead of the values in the 2014EPA_EGU dataset. In the 2011 NEI, the EPA EGU estimated emissions that were derived from the MATS testing program were used ahead of the S/L/T values, unless the S/L/T submittal indicated that the value was from either a CEM or a recent stack test. For the 2014 NEI, we used the S/L/T-reported values wherever they were reported (unless they were tagged out as an outlier), including where a MATS-based value existed in the 2014EPA EGU dataset. In addition, we made the MATS emission factors available to S/L/T agencies far in advance of the data being submitted so that facilities and/or S/L/T agencies could choose to use that information to compute emissions if it was most applicable.

We assumed that all heat input came from the primary fuel, and the EFs used reflected only that primary fuel. This introduces a small amount of uncertainty as many EGU units use a small amount of alternative fuels. The resultant unit-level estimates had to be loaded into EIS at the process-level to meet the EIS requirement that emissions can only be associated with the most detailed level. To do this for the EGU sectors, we needed to bridge the unit level (i.e., the boiler or gas turbine unit as a whole) to the process level (i.e., the individual fuels burned within the units). So, the EPA emissions were assigned to a single process for the primary fuel that was used by the responsible S/L/T agency for reporting the largest portion of their emissions. The EPA emissions were then “tagged out” wherever the S/L/T agency had reported the same pollutant at any process within the same emission unit. This approach prevented double counting of a portion of the S/L/T-reported emissions in cases where the S/L/T agency may have reported a unit’s emissions using two different coal processes and a small oil process, for example.

The matching of the 2014EPA_EGU dataset to the responsible agency facility, unit and process IDs was done largely by using the ORIS plant and CAMD boiler IDs as found in the CAMD heat input activity dataset, and linking these to the same two IDs as had been stored in EIS. We also compared the facility names and counties for agreement between the S/L/T-reported values and those in CAMD, and we made revisions to the matches wherever discrepancies were noted. As a final confirmation that the correct emissions unit and a reasonable process ID in EIS had been matched to the EPA data, the magnitudes of the SO_2 and NOx emissions for all preliminary matches were compared between the S/L/T agency-reported datasets and the EPA dataset. We identified and resolved several discrepancies from this emissions comparison.

<u>Alternative facility and unit IDs needed for matching with other databases</u>

The 2014 NEI data contains two sets of alternate unit identifiers related to the ORIS plant and CAMD boiler IDs (as found in the CAMD heat input activity dataset) for export to the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling file. The first set is stored in EIS with a Program System Code (PSC) of “EPACAMD.” The alternate unit IDs are stored as a concatenation of the ORIS Plant ID and CAMD boiler ID with “CAMDUNIT” between the two IDs. These IDs are exported to the SMOKE file in the fields named ORIS_FACILITY_CODE and ORIS_BOILER_ID. These two fields are used by the SMOKE processing software to replace the annual NEI emissions values with the appropriate hourly CEM values at model run time. The second set of alternate unit IDs are stored in EIS with a PSC of “EPAIPM” and are exported to the SMOKE file as a field named “IPM_YN.” The SMOKE processing software uses this field to determine if the unit is one that will have future year projections provided by the integrated planning model (IPM). The storage format of these alternate EPAIPM unit IDs, in both EIS and in the exported SMOKE file, replicates the IDs as found in the National Electric Energy Data

System (NEEDS) database used as input to the IPM model. The NEEDS IDs are a concatenation of the ORIS plant ID and the CAMD boiler ID, with either a "_B_" or a "_G_" between the two IDs, indicating "Boiler" or "Generator." The ORIS Plant IDs and CAMD boiler IDs as stored in the CAMD Business System(CAMDBS) dataset and in the NEEDS database are almost always the same, but there are occasional differences for the same unit. The EPACAMD alternate unit IDs available in the 2014 NEI are believed to be a complete set of all those that can safely be used for the purpose of substituting hourly CEM values without double-counting during SMOKE processing. The EPAIPM alternate unit IDs in the 2014 NEI are not a complete listing of all the NEEDS/IPM units, although most of the larger emitters do have an EPAIPM alternate unit ID. The NEEDS database includes a much larger set of smaller, non-CEM units.

3.5 Landfills

The point source emissions in the EPA's Landfill dataset includes CO and 28 HAPs, as shown in Table 3-5. This set of pollutants was included in the 1999 NEI, and we continue to use the same set of pollutants each year for a consistent time series. To estimate emissions, we used the methane emissions reported by landfill operators in compliance with Subpart HH of the Greenhouse Gas Reporting Program (GHGRP) as a "surrogate" activity indicator. We converted the methane as reported in Mg CO2 equivalent to Mg as actual methane emitted by dividing by 23 (the Global Warming Potential of methane believed to be used in the version of the 2014 GHGRP facility inventory) to get MG methane emitted, and then multiplied by 1.1023 to get tons methane emitted[5]. We created emission factors for CO and the 28 HAPs on a per ton of methane emitted basis using the default concentrations (ppmv) in AP-42 Section 2.4 (final section dated Jan 1998), Table 2.4-1. The concentrations for toluene and benzene were taken from Table 2.4-2 of AP-42, for the case of "no or unknown" co-disposal history. Per Equation 4 of that AP-42 section, Mp=Qp x MWp x constant (at any given temperature). Writing this equation twice, for the mass of any pollutant "P" and for methane (CH4), and dividing M_p by M_{CH4} yields:

M_p / M_{CH4} = (Qp x MWp x k) / Q_{CH4} x MW_{CH4} x k) = (Qp/Q_{CH4}) x (MWp/MW_{CH4}), units of pounds p/pound CH4

A rearrangement of Equation 3 of that AP-42 section provides Qp/ Q_{CH4} = 1.82 x Cp/1000000, where the 1.82 is based upon a default methane concentration of 55 % (550,000 ppm). Plugging this expression for Qp/ Q_{CH4} into the first expression yields:

M_p / M_{CH4} = (1.82 x Cp/1000000) x (MWp/ MW_{CH4}) x 2000, units of pounds p/ton CH4

M_p / M_{CH4} = (1.82 x Cp/1000000) x (MWp/16) x 2000 = Cp x MWp / 4395.6

Table 3-5: Landfill gas emission factors for 29 EIS pollutants

Pollutant code	Pollutant description	MW	ppmv	MW x ppmv	lbs/Ton CH_4
CO	Carbon monoxide	28.01	141	3949.41	0.89849
108883	toluene	92.13	39.3	3620.709	0.82371
1330207	Xylenes	106.16	12.1	1284.536	0.29223
75092	Dichloromethane (methylene chloride)	84.94	14.3	1214.642	0.27633

[5] For more information on CO_2 equivalent and global warming potential, please refer to EPA's page "Understanding Global Warming Potentials".

Pollutant code	Pollutant description	MW	ppmv	MW x ppmv	lbs/Ton CH_4
7783064	Hydrogen sulfide	34.08	35.5	1209.84	0.27524
127184	Perchloroethylene (tetrachloroethylene)	165.83	3.73	618.5459	0.14072
110543	Hexane	86.18	6.57	566.2026	0.12881
100414	Ethylbenzene	106.16	4.61	489.3976	0.11134
75014	Vinyl chloride	62.5	7.34	458.75	0.10437
79016	Trichloroethylene (trichloroethene)	131.4	2.82	370.548	0.08430
107131	Acrylonitrile	53.06	6.33	335.8698	0.07641
75343	1,1-Dichloroethane (ethylidene dichloride)	98.97	2.35	232.5795	0.05291
108101	Methyl isobutyl ketone	100.16	1.87	187.2992	0.04261
79345	1,1,2,2-Tetrachloroethane	167.85	1.11	186.3135	0.04239
71432	benzene	78.11	1.91	149.1901	0.03394
75003	Chloroethane (ethyl chloride)	64.52	1.25	80.65	0.01835
71556	1,1,1-Trichloroethane (methyl chloroform)	133.41	0.48	64.0368	0.01457
74873	Chloromethane	50.49	1.21	61.0929	0.01390
75150	Carbon disulfide	76.13	0.58	44.1554	0.01005
107062	1,2-Dichloroethane (ethylene dichloride)	98.96	0.41	40.5736	0.00923
106467	Dichlorobenzene	147	0.21	30.87	0.00702
463581	Carbonyl sulfide	60.07	0.49	29.4343	0.00670
108907	Chlorobenzene	112.56	0.25	28.14	0.00640
78875	1,2-Dichloropropane (propylene dichloride)	112.99	0.18	20.3382	0.00463
75354	1,1-Dichloroethene (vinylidene chloride)	96.94	0.2	19.388	0.00441
67663	Chloroform	119.39	0.03	3.5817	0.00081
56235	Carbon tetrachloride	153.84	0.004	0.61536	0.00014
106934	Ethylene dibromide	187.88	0.001	0.18788	0.00004
7439976	Mercury (total)	200.61	0.000292	0.05857812	0.00001

3.6 Other/carry forward

This EPA dataset is used to fill in miscellaneous emissions which were not reported by S/L/T agencies for 2014, and for which no EPA dataset has 2014 emissions, but which are believed to exist in 2014. These unreported facilities and pollutants were identified as part of the QA review steps performed on the S/L/T data (see Section 3.1.1). A total of 212 unique facilities and 12 different pollutants are represented in this dataset. The only HAP pollutant included in this dataset is coke oven emissions, added for five facilities (three in Ohio, one each in Virginia and Michigan), where the States reported other emissions for the facility but not the coke oven emissions pollutant. The 2011 NEI coke oven emissions for these five facilities were carried forward to this 2014 dataset as is, without change. All other pollutants added were criteria pollutants, and only where 2011 emissions values indicated that emissions had been greater than the required pollutant reporting thresholds. Many of these additions were for Maricopa County, Arizona (15 facilities) and the Navajo Nation (12 facilities), neither of which submitted any point emissions for 2014, and for Indiana (171 facilities), which submitted a large amount of facilities including both criteria and many HAP pollutants but which did not get some criteria pollutants included in 2014 for some facilities due to a processing error. In addition, eight facilities in California and one facility in Wisconsin were also included in this dataset. All emissions values for 2014 were set equal to the 2011 NEI v2 emissions values.

3.7 BOEM

The U.S. Department of the Interior, Bureau of Ocean and Energy Management (BOEM) estimates emissions of CAPs in the Gulf of Mexico from offshore oil platforms in Federal waters, and these data have been previously incorporated into the NEI. The 2014 offshore data were not available in time for inclusion in the 2014 v1 NEI, thus, we carried forward the 2011 BOEM emissions. The only step taken with the data from BOEM for 2011 was convert the data to the CERS format needed to load to EIS, which included using the code "DM" for Federal waters in place of a state postal code. More information on these data is available at the BOEM 2011 Gulfwide Emission Inventory website.

3.8 PM species

The "2014EPA_PMspecies" dataset was created by the EPA by calculating speciated PM2.5 emissions from all contains a speciation of PM2.5-PRI into five component species (EC, OC, SO_4, NO_3, and other). These calculations were made using the EPA's 2011 version 6.3 emissions modeling platform available from the Emissions Modeling Clearinghouse website. In addition, this dataset contains a copy of PM2.5-PRI and PM10-PRI pollutants from locomotive diesel engines processes at railyards and aircraft ground support equipment using diesel fuel. These copied data records are simply relabeled as PM-diesel pollutants so that the diesel PM "pollutant" can more easily be identified in the inventory. No stationary sources running with diesel fuel are labeled as PM-diesel "pollutants".

3.9 Point source approach for the 2014v2 NEI

For the 2014v2 point sources, two methods of taking S/L/T edits were used. The first method involved having the S/L/Ts send Excel spreadsheet "change sheets" showing the existing 2014v1 data for selected facilities (1,561 total) based on initial risk projections to identify potential outliers as a part of the National Air Toxics Assessment (NATA) emissions review. Two sets of changes sheets containing 2014v1 data were provided: 1) process level emissions, and 2) release point geographic coordinates and parameters. U.S. EPA then reviewed and incorporated all accepted changes into one of two U.S. EPA emissions edit datasets (2014EPA_NATASLT or 2014EPA_NATA) or into the EIS facility inventory. U.S. EPA had originally intended to only use this method as it was deemed easier to review and track changes, which were intended be limited to significant errors that would potentially impact NATA results. Due to request by S/L/Ts, U.S. EPA included the second method for S/L/Ts to submit the NATA review edits to either their agency emissions datasets or to the facility inventory in EIS directly. The U.S. EPA then pulled any significant emission changes from the S/L/T emissions datasets and wrote those into one of the two U.S. EPA emissions edit datasets. Any edits submitted by S/L/Ts directly to the EIS facility inventory were also available and used for production of the 2014v2 NEI point source file via this second method.

In addition to making edits to their own data (via either of the two methods) S/L/T, EPA Regional Offices and EPA TRI program staff reviewed and provided changes to the 2014v1 EPA augmented data (e.g., data from the TRI program or the HAP augmentation datasets) via the change sheet method.

Emissions changes from the two methods are in one of two U.S. EPA emissions data sets: 2014EPA_NATASLT and 2014EPA_NATA. Different datasets were used to distinguish changes to EPA data from changes to S/L/T data. There are approximately 60 facilities with NATA-related changes contained in the 2014EPA_NATA dataset and 110 facilities with NATA-related changes in the 2014EPA_NATASLT dataset. Other NATA-related changes include the tagging out (removal) of emissions from processes or facilities that were determined via the S/L/T review to have not been operating or were double counted.

For the second method (S/L/T direct submittal to EIS), U.S. EPA originally planned that any facility that showed a difference of at least 50 tons (annual) in total criteria pollutants, either an increase or a decrease, compared to the 2014v1 facility criteria pollutant total would be considered significant enough to incorporate those edits into the 2014v2 NEI. It was desirable to limit the volume of submitted edits to only those that were significant due to the time and resources needed to build a completely new 2014v2 point inventory that would also negate the benefits of all QA review and confidence developed in the 2014v1 file.

A numeric comparison of facility-pollutant sums as they appeared in the S/L/T 2014 emissions datasets as they appeared on June 16, 2017 (after the close of the S/L/T 2014v2 submittal window) to the corresponding sums in the 2014v1 NEI was done. The absolute values of each pollutant-specific difference (for criteria pollutants) were added together to get a facility total change value from the 2014v1 NEI. This step avoided having any criteria pollutants that appeared in the 2014v1 file only due to EPA Augmentation steps (PM Augmentation or TRI ammonia sources) from impacting the results. A set of 368 facilities that were either new or edited by more than 50 tons was identified. For these 368 facilities, all pollutants (including both criteria and hazardous), at all processes, were submitted to emissions dataset “2014EPA_NATASLT”. This was one of two emissions datasets (the other being “2014EPA_NATA”) that were used to override or add to the base “2014 NEI Final V1” file used for the 2014v2 selection. Along with the S/L/T submitted emissions values, all calculation parameters, operating details, and reporting period details that were present in the edited S/L/T 2014 datasets were also written to “2014EPA_NATASLT”. In addition to these “primary” reported pollutants, it was necessary to also develop updated estimates for any PM Augmentation, HAP Augmentation, Chrome speciation, and 7 PM species values that had been derived from those primary pollutants. Those were all developed “off-line” from EIS for the small subset of 2014v1 records being impacted, using the same ratios that EIS has stored and uses for those augmentations. The derived edited values were also written to the “2014EPA_NATASLT” emissions dataset. Where the S/L/T edited 2014 datasets included additional HAPs not seen in the S/L/Ts v1 submittals, and those HAPs had been accounted for in 2014v1 via HAP Augmentation or TRI emissions records, the v1 emissions records were tagged out from the “2014 NEI Final V1” file as well.

The comparison at the facility-pollutant level back to 2014v1 totals also revealed some pollutants that existed for a facility in 2014v1, but which were completely absent from the S/L/T 2014 edited emissions datasets as they appeared in June 2017. Where these pollutants had appeared in 2014v1 due to S/L/T emissions records (as opposed to EPA augmentation or TRI records) which were now absent, it was necessary to tag out the old emissions values from the “2014 NEI Final V1” file so that they would not be picked up from there and included again as part of the 2014v2 selection. Where these deleted pollutants were VOC or PM10-FIL values that had been used to derive HAP Augmentation values, the augmented values were similarly tagged out from “2014 NEI Final V1”.

Apart from the planned method 2 approach to identify and amend facilities with significant (greater than 50 ton/year) criteria pollutant changes, a file was created of facilities that were entirely new in the S/L/T 2014v2 edits, regardless of emission amounts. These records, along with any needed U.S. EPA augmentation or speciation records, were also written to the “2014 NEI Final V1” file. The $PM_{2.5}$ species (i.e., EC, OC, etc.) from these datasets were not used, however, because we re-speciated PM after combining all other datasets to ensure consistency with the 2014v2 $PM_{2.5}$ emissions.

In addition to the above edits received from S/L/Ts, U.S. EPA also received a set of point emissions data for 2014 from the US Bureau of Ocean Management (BOEM) for off-shore oil and gas platforms in federal waters in the Gulf of Mexico. These data had not been available in time for the 2014v1 NEI, so the 2011 data for those platforms had been included instead as a surrogate for 2014. The actual 2014 BOEM emissions data had been loaded into EIS by BOEM in time for the 2014v2 selection, and so that singular responsible agency dataset was included as part of the selection hierarchy for 2014v2. All facilities, processes, and pollutants that were contained in the "2014 NEI Final V1" file from the earlier 2011 surrogate data but were not also in the actual 2014 BOEM dataset were tagged out of the "2014 NEI Final V1" file being used as part of the selection.

Finally, U.S. EPA conducted a review of the v1 mercury emissions and made changes primarily to municipal waste combustors and electric arc furnaces. For MWCs, some S/L/T data were found to be under or overestimated and were corrected and missing data were gap-filled. For electric arc furnaces, missing data were gap-filled. Data revisions provided by S/L/T were put into the 2014EPA_NATASLT dataset; EPA gap-filled emissions were included in 2014EPA_NATA. More details on mercury emissions are provided in Section 2.7.

The 2014v2 EPA datasets were combined with the 2014v1 NEI in the hierarchy provide in Table 3-6. See Table 3-1 for the 2014v1 NEI hierarchy. A process level summary on the 2014v2 NEI will provide the data source from Table 3-1 for any data from the 2014v2 NEI dataset. For the 7 PM species, the process level summaries will not include the "2014EPA_PMspeciesV2" dataset name, but rather the dataset from which the $PM_{2.5}$ was derived.

Table 3-6: Data sets and selection hierarchy used for the 2014v2 point source data category

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014EPA_NATA	Changes to EPA data (i.e., TRI and HAP augmentation data from 2014v1) resulting from the 2014NATA review and the 2014 updated rail yard emissions, covering over 800 rail yards.	1
2014EPA_NATASLT	Changes to S/L/T data resulting from the 2014 NATA emissions review and changes to S/L/T data that met the criteria for use in the NEI.	2
2014EPA_BOEM	2014 CAP Emissions from Offshore oil platforms located in Federal Waters in the Gulf of Mexico developed by the U.S. Department of the Interior, Bureau of Ocean and Energy Management, Regulation, and Enforcement. The state code for data from this data set is "DM" (Federal Waters). For the 2014v2 NEI, we replaced the 2011 BOEM data with this dataset.	3
2014_NEI Final V1	This dataset contains the data from the selection done for the 2014v1 NEI, except for any data tagged out due to the NATA review, and to replace the 2011 BOEM data and 2011 rail yards with 2014 data	4
Overrides to the above: In addition to the 2014v1 overrides, we used the 2014EPA_PMSpeciesV2 dataset to override each of the 7 PM Species: elemental (black) carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), the remainder of PM25-PRI (PMFINE), diesel fine particulate (DIESEL-PM25) and diesel coarse particulate (DIESEL-PM10) present in any of the above datasets. The 2014EPA_PMSpeciesV2 dataset was created by speciating the $PM_{2.5}$ from a draft 2014v2 comprised of the above 4 datasets.		

3.10 References for point sources

1. Dorn, J, 2012. *Memorandum: 2011 NEI Version 2 – PM Augmentation approach.* Memorandum to Roy Huntley, US EPA. (PM augmt 2011 NEIv2 feb2012.pdf, accessible in the reference documents of the 2008 NEI documentation.
2. Strait et al. (2003). Strait, R.; MacKenzie, D.; and Huntley, R., 2003. PM Augmentation Procedures for the 1999 Point and Area Source NEI, 12th International Emission Inventory Conference – "Emission Inventories – Applying New Technologies", San Diego, April 29 – May 1, 2003.

4 Nonpoint sources

This section includes all sources that are in the nonpoint data category. These sources are reported/generated at the county level, though some sources such as rail lines and shipping lanes and ports are more-finely resolved to the county/shape identifier (ID) (polygon) level. Stationary sources that are inventoried at facilities and stacks (coordinates) are discussed in the previous Point Section 3. This section discusses all sources in the Nonpoint inventory except Biogenics which is discussed in Section 8. Some "nonroad" mobile sources such as trains and commercial marine vessels reside in the nonpoint data category and are discussed here and not in the Nonroad Equipment Section 5.

4.1 Nonpoint source approaches

Nonpoint source data are provided by state, local, and tribal (S/L/T) agencies, and for certain sectors and/or pollutants, they are supplemented with data from the EPA. This section describes the various sources of data and the selection priority for each of the datasets to use for building the National Emissions Inventory (NEI) when multiple data sources are available for the same emissions source. Section 2.2 provides more information on the data selection process.

4.1.1 Sources of data overview and selection hierarchies

Table 4-1 describes the datasets comprising most of the nonpoint inventory, and the hierarchy for combining these datasets in construction of the NEI. Agricultural field burning, commercial marine vessels and locomotives utilize sector-specific databases provided in Table 4-2, Table 4-3 and Table 4-4, respectively. While the bulk of these datasets are for stationary sources of emissions, some of these datasets contain mobile sources so that emissions from ports, shipping lanes and rail yards could be included as nonpoint sources. The following four tables includes the rationale for why each dataset was assigned its position in the hierarchy. We excluded certain pollutants from stationary sources in the 2014 NEI: greenhouse gases and pollutants in the pollutant groups "dioxins/furans" and "radionuclides"[6]. The EPA has not evaluated the completeness or accuracy of the S/L/T agency dioxin and furan values nor radionuclides, and does not have plans to supplement these reported emissions with other data sources to compile a complete estimate for dioxin and furans nor radionuclides as part of the NEI.

Table 4-1: Data sources and selection hierarchy used for most nonpoint sources

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014EPA_PMspecies _V2	Adds speciated $PM_{2.5}$ data to resulting selection. This is a result of offline emissions speciation where the resulting PM25-PRI selection emissions are split into the 5 PM species: elemental (black) carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). Also adds a copy of PM2.5-PRI and PM10-PRI from diesel engines, relabeled as DIESEL-PM pollutants. See Section 2.2.5.	1

[6] Dioxins/furans include all pollutants with pollutant category name of: Dioxins/Furans as 2,3,7,8-TCDD TEQs, or Dioxins/Furans as 2,3,7,8-TCDD TEQs – WHO2005, both of which were valid pollutant groups for reporting 2014 emissions. Radionuclides have the pollutant category name of "radionuclides" The specific compounds and codes are in the pollutant code tables in EIS.

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014PMaug_v2NP	Adds nonpoint inventory PM species to fill in missing S/L/T agency data or make corrections where S/L/T agency data have inconsistent emissions across PM species. Uses the PM Augmentation Tool for processes covered by that database. For SCCs without emission factors in the tool, checks/corrects discrepancies or missing PM species using basic relationships such as ensuring that PMXX FIL is less than or equal PMXX PRI (See Section 2.2.4).	2
Responsible Agency Selection	S/L/T agency submitted data; multiple datasets – one for each reporting agency. These data are selected ahead of other datasets. The only other situation where S/L/T agency emissions are not used is where certain records are tagged in the Emissions Inventory System (EIS) (at the specific source/pollutant level). This occurs: 1) for hierarchy purposes to allow EPA nonpoint emissions to be used ahead of S/L/T agency data where states asked for EPA data to be used in place of their data and 2) where S/L/T agency data were suspected outliers.	3
2014EPA_Cr_Aug_v2	Hexavalent and trivalent chromium speciated from S/L/T agency reported chromium. The EIS augmentation function creates the dataset by applying multiplication factors by source classification code (SCC) to S/L/T agency "total" chromium. See Section 2.2.2.	4
2014EPA_HAPAug _V2	HAP data computed from S/L/T agency criteria pollutant data using ratios of HAP to CAP emission factors. The emission factors used to create the ratios are the same emission factors as are used in creating the EPA estimates (i.e., in the EPA nonpoint emission tools). This dataset is below the S/L/T agency data so that the S/L/T agency HAP data are used first. HAP augmentation is discussed in Section 2.2.3.	5
2014EPA_NONPOINT _V2	All nonpoint EPA estimates are included in this dataset except those listed elsewhere in this table. This dataset includes sources with and without point source subtraction and outputs from most of the EPA tools. This dataset also includes biogenic emissions. Examples of sources in this dataset include: fertilizer, most livestock, industrial and commercial/institutional fuel combustion, residential wood combustion, solvent utilization, oil and gas exploration and production, open burning, agricultural burning, road and construction dust, and portable fuel containers.	6
2014_EPA_NP_ from2011	2011 v2 NEI data from 2011 EPA nonpoint estimates that were not updated for 2014: livestock waste from ducks, geese, horses, goats and sheep.	7
2014EPA_Airports	2014 aircraft in-flight emissions (Lead only)	8

Table 4-2: Data sources and selection hierarchy used for the Agricultural Field Burning sector

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014EPA_PMspecies _V2	Adds speciated $PM_{2.5}$ data to resulting selection. This is a result of offline emissions speciation where the resulting PM25-PRI selection emissions are	1

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
	split into the 5 PM species: elemental (black) carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). Also adds a copy of PM2.5-PRI and PM10-PRI from diesel engines, relabeled as DIESEL-PM pollutants. See Section 2.2.5.	
2014v2_AgFires		2

Table 4-3: Data sources and selection hierarchy used for the Commercial Marine Vessels sector

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014EPA_PMspecies _V2	Adds speciated $PM_{2.5}$ data to resulting selection. This is a result of offline emissions speciation where the resulting PM25-PRI selection emissions are split into the 5 PM species: elemental (black) carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). Also adds a copy of PM2.5-PRI and PM10-PRI from diesel engines, relabeled as DIESEL-PM pollutants. See Section 2.2.5.	1
2014LADCO_CMV	Adds speciated $PM_{2.5}$ data to resulting selection. This is a result of offline emissions speciation where the resulting PM25-PRI selection emissions are split into the 5 PM species: elemental (black) carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). Also adds a copy of PM2.5-PRI and PM10-PRI from diesel engines, relabeled as DIESEL-PM pollutants. See Section 2.2.5.	2
2014SLTv2_CMV	S/L/T agency submitted CMV data for 2014v2. See Section 4.19.	3
2014Augv2_CMV	HAP data computed from S/L/T agency criteria pollutant CMV data using ratios of HAP to CAP emission factors. The emission factors used to create the ratios are the same emission factors as are used in creating the EPA estimates (i.e., in the EPA nonpoint emission tools). HAP augmentation is discussed in Section 2.2.3.	4
2014EPAv2_CMV	EPA commercial marine vessel (CMV) emissions estimates. See Section 4.19.	5

Table 4-4: Data sources and selection hierarchy used for the Locomotives sector

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014EPA_PMspecies _V2	Adds speciated $PM_{2.5}$ data to resulting selection. This is a result of offline emissions speciation where the resulting PM25-PRI selection emissions are split into the 5 PM species: elemental (black) carbon (EC), organic carbon (OC), nitrate (NO3), sulfate (SO4), and the remainder of PM25-PRI (PMFINE). Also adds a copy of PM2.5-PRI and PM10-PRI from diesel engines, relabeled as DIESEL-PM pollutants. See Section 2.2.5.	1
2014SLTv2_Rail	S/L/T agency submitted locomotives data for 2014v2. See Section 4.20.	2
2014AUGv2_Rail	HAP data computed from S/L/T agency criteria pollutant locomotives data using ratios of HAP to CAP emission factors. The emission factors used to create the ratios are the same emission factors as are used in creating the EPA estimates (i.e., in the EPA nonpoint emission tools). HAP augmentation is discussed in Section 2.2.3.	3

Dataset name	Description and Rationale for the Order of the Selected Datasets	Order
2014EPAv2_Rail	EPA locomotive (referred to as "rail" in this document) emissions estimates. See Section 4.20.	4

The EPA developed all datasets listed above except for the "Responsible Agency Selection," which contains only S/L/T agency data. We used various methods and databases to compile the EPA generated datasets, which are further described in subsequent subsections. The primary purpose of the EPA datasets is to add or "gap fill" pollutants or sources not provided by S/L/T agencies, to resolve inconsistencies in S/L/T agency-reported pollutant submissions for PM (Section 2.2.4) and to speciate S/L/T agency reported total chromium into hexavalent and trivalent forms (Section 2.2.2).

The hierarchy or "order" provided in Table 4-1 through Table 4-4 defines which data are preferentially used when multiple datasets could provide emissions for the same pollutant and emissions process. The dataset with the lowest order on the list is preferentially used over other datasets. In addition to the order of the datasets, the hierarchy was also influenced by the EIS feature of data tagging (Section 2.2.6). Any data that were tagged by EPA in any of the datasets were not used. S/L/T agency data were tagged for two reasons: 1) S/L/Ts requested that their data not be used, and 2) EPA found unexpected pollutants for a source. Many EPA nonpoint data were tagged, primarily because of S/L/T feedback in the Nonpoint Survey (see Section 4.1.2).

Special caveat on backfilling with non-S/L/T data

The hierarchal backfilling that occurs in the selection process can create unexpected artifacts to the resulting inventory selection. For example, if S/L/T agencies do not submit emissions for a pollutant, and emissions for that pollutant exist in other datasets, then non-S/L/T data will show up in the NEI selection for these pollutants. If S/L/T agencies report zero emissions, then backfilling with other datasets will not occur. There are two ways that S/L/T agencies can prevent inappropriately backfilled emissions from being included in the NEI: 1) S/L/T agencies can submit zeros for any pollutant they do not want filled in (the EPA data will otherwise fill in for all pollutants that are on the nonpoint expected pollutant list), or 2) the EPA can add tags to backfill datasets that prevent the tagged pollutants from being included in the NEI. The first option is more straightforward and takes care of any possible augmentation from the numerous other datasets in the selection hierarchy.

4.1.2 The Nonpoint Survey

The purpose of the nonpoint survey is to increase the accuracy and transparency in how the nonpoint inventory is built using EPA and S/L/T agency data. The nonpoint inventory includes many source categories that can overlap with sources that can also be reported as a point source; and because the potential for overlap varies by source category and reporting agency, it is important that we have information about how each agency treats inventory development for all nonpoint source types. For example, some agencies voluntarily report gas stations as point sources, which are sources that overlap with the nonpoint refueling emissions used by most states. Thus, in building the EPA nonpoint inventory, the EPA needs to know whether *all* gas stations are reported as point sources or only some of them (such as for certain counties), so that we know to what degree we should include nonpoint refueling emissions in the NEI for that state or local area.

The nonpoint survey is available only to reporting agencies and is organized by emissions sector, where the first yes/no question is whether the sector exists in an agency's jurisdiction. If the answer is "no", then the user moves on to the next sector. If the answer is "yes", then the survey provides numerous additional questions using drop-down lists for agencies to choose responses. These questions include whether the data are reported solely in the point or nonpoint inventories and whether the EPA or alternative nonpoint SCCs are used by the S/L/T agency. The survey also allows the S/L/T agency to specify their preference for the NEI to include EPA emissions rather than S/L/T emissions; this goes against the hierarchies in Table 4-1, Table 4-2, Table 4-3, and Table 4-4; therefore, a response to use EPA emissions rather than S/L/T emissions help to automate the generation of S/L/T nonpoint "tags". When the entire survey is complete, EPA generates a couple sets of data tags:

1) EPA tags: where S/L/T agencies indicate that the sources do not exist in their area, or where all data are reported in the point submittal. Any EPA data for these sources will be tagged out.
2) S/L/T tags: where S/L/T agencies indicate that they would prefer that the EPA data are used instead of their nonpoint submittal. Without the tags, the EPA data will not be used where S/L/T agency data exists because the EPA data are lower in the selection hierarchy (see Table 3-1).

To explain the nonpoint survey for the 2014 NEI cycle, the EPA provided a webinar to S/L/T agencies on the nonpoint survey in July of 2015. This webinar is available on the available on the Air Emissions Inventory Training website.

Nonpoint Survey for version 2 of the 2014 NEI

It is important to note that the nonpoint survey was sent to the S/L/Ts prior to the beginning of the 2014 NEI cycle, and used for the development of version 1 of the 2014 NEI. We did not send out a new survey prior to the development of version 2 of the 2014 NEI; therefore, unless S/L/Ts informed us otherwise, all survey responses were carried forward from 2014v1 to this 2014v2 NEI.

4.1.3 Nonpoint PM augmentation

Section 2.2.4 provides an overview of PM augmentation in the 2014 NEI and explains that we used a PM Augmentation Tool. The tool creates two output tables for each data category: Additions and Overwrites. We post-processed these output tables prior to loading the data in the EIS. In this section, we describe the post-processing issues that are specific to the nonpoint inventory.

We post-processed these data to prevent inadvertently overriding S/L/T agency primary PM_{10} and $PM_{2.5}$ data (i.e., EIS pollutants PM10-PRI and PM2.5-PRI). The PM Augmentation Tool computes the condensable (PM-CON) and filterable PM components (PM10-FIL and PM25-FIL) and re-computes primary PM_{10} and $PM_{2.5}$ when the sum of the components differed by more than the slim tolerance assumed by the tool. We decided to remove these "overwrites" for primary PM_{10} and $PM_{2.5}$ whenever the summed PM from the components was within 0.01 tons of S/L/T-provided primary PM_{10} or $PM_{2.5}$ totals. This tolerance was higher than the one used by the tool, but we wanted the NEI to reflect that the data source for the primary PM_{10} and $PM_{2.5}$ was from the S/L/T agency and not the EPA augmentation dataset.

We used summed components from the tool to overwrite the S/L/T agency data in the NEI selection when this difference exceeded 0.01 tons and S/L/T agencies reported both primary PM_{10} and $PM_{2.5}$; however, this was a rare occurrence. Nationally, these overwrites resulted in only a 264-ton increase in primary $PM_{2.5}$ and was found primarily for fuel combustion sources where primary PM_{10} greatly exceeded primary $PM_{2.5}$ and computed condensable and filterable components indicated that the submitted primary $PM_{2.5}$ was too low. In some cases, S/L/T agencies reported all 5 PM components, but the sum of (for example) PM-CON and PM25-FIL was different from S/L/T-reported PM25-PRI. We recommended that the S/L/T agencies review PM25-PRI overwrite values during the NEI review period prior to NEI release.

4.1.4 Nonpoint HAP augmentation

For nonpoint sources, we derived HAP augmentation ratios were derived from the emission factors used to develop the EPA nonpoint source estimates. The EPA nonpoint HAP emission estimates are computed in EPA nonpoint spreadsheet and database "tools". Because we used the same emission factors for these augmentation ratios, the ratios of HAP to CAPs for augmented S/L/T agency data are the same as the HAP to CAP ratios for the EPA-only data.

For access by non-EIS users, the zip file called "2014HAPAugFactors.zip" provides the emission ratios that the EPA used for augmenting point and nonpoint data categories. The nonpoint HAP augmentation factors were greatly improved as compared to what was used for the 2011 NEI, particularly for the oil and gas sector. For 2014, instead of national average factors, we added county-specific factors to the HAP augmentation, consistent with what is in the Oil and Gas Tool. We made this improvement in response to comments from the National Oil and Gas Committee that gas composition is highly variable and is dependent on geographic formations at a finer spatial granularity than the oil and gas basin.

The EPA staff responsible for the nonpoint sectors use their discretion for how to augment HAP emissions and work with the S/L/T agencies to reflect as complete and accurate set of pollutants as possible for the many source types. In general, if a S/L/T agency submitted a partial list of the HAPs that would be augmented for a given category, then we allowed the missing HAPs to be gap-filled with the HAP augmentation data. These missing HAPs are determined by comparing the Expected Pollutant List for Nonpoint SCCs with those that S/L/T agencies submitted. However, this approach has a risk of potentially violating VOC mass balance, whereby the sum of the VOC HAPs exceeds the VOC total. Thus, special cases occur when such problems are identified. For example, for agricultural burning we removed the S/L/T agency HAPs and used only the HAP augmentation (computed from the S/L/T-submitted CAPs.

We also tagged records from the HAP Augmentation dataset where they duplicated records in certain other EPA datasets, but for which the EIS selection hierarchy would not do everything we wanted. Thus, we tagged HAP augmentation values where the HAP Augmentation pollutant belonged to the same pollutant group as a *different* pollutant reported by the S/L/T agency. For example, if the HAP Augmentation dataset had o-xylene, and the S/L/T agency reported total xylenes, then we tagged the o-xylene in the HAP Augmentation dataset. The resultant tagging was done for the xylenes, Polycyclic Aromatic Hydrocarbons (PAHs) and cresols groups listed in Table 3-3 and discussed in Section 3.1.5 in the context of a similar issue that comes up using the Toxics Release Inventory (TRI) for point source augmentation.

4.1.5 EPA nonpoint data

For the 2014 NEI, the EPA developed emission estimates for many nonpoint sectors in collaboration with a consortium of inventory developers from various state agencies regional planning organizations called the NOnpoint Method Advisory (NOMAD) Committee. The broad NOMAD committee meets monthly to discuss the overall progress on the various sectors for which tools and/or estimates are being developed or refined. More detailed NOMAD subcommittees were established for key nonpoint source categories/sectors including, but not limited to: oil and gas exploration and production, residential wood combustion, agricultural NH_3 sources including agricultural pesticides, fertilizer and livestock, various dust sources, solvents, industrial and commercial/institutional fuel combustion, mercury, and gasoline distribution. These subgroups collaborate on methodologies, emission factors, and SCCs, allowing the EPA to prepare the "default" emission estimates for S/L/T agencies using the group's final approaches. The NOMAD committees were formed in preparation for the 2014 NEI; however, time and resource constraints limited the scope of some of the work that could be accomplished. For example, the mercury NOMAD team identified several source categories where methodology and/or activity data need revision, and this collaboration will propagate into a future NEI, but for the 2014 NEI, 2011 NEI estimates are carried forward.

During the 2014 NEI inventory development cycle, S/L/T agencies, using the nonpoint survey (Section 4.1.2), could accept the NOMAD/EPA estimates to fulfill their nonpoint emissions reporting requirements. The EPA encouraged S/L/T agencies that did not use the EPA's estimates or tools to improve upon these "default" methodologies and submit further improved data.

Table 4-5 and

Table 4-6 describe the sectors for which EPA developed emission estimates. They separately list emissions sectors entirely comprised of data in the nonpoint (i.e., not point source) data category (Table 4-5), such as residential heating, from sectors that may overlap with the point sources (

Table 4-6). For sectors that overlap, some emissions will be submitted as point sources and other emissions in the same state or county are submitted as nonpoint, for example, fuel combustion at commercial or institutional facilities. The EPA attempted to include all EPA-estimated nonpoint emissions that overlap if it was determined that the category was missing from the S/L/T agency data.

All EPA methodologies are provided in zip files posted on the 2014v2 Supplemental Nonpoint data FTP site, which is the directory containing most supporting data files listed in Table 4-5 and

Table 4-6. Agricultural field burning and nonpoint mercury estimates are provided in other directories listed in Table 4-5. Emission sources that use data from the 2014v1 NEI are identified in the column "Carried Forward?" in these tables. The SCCs associated with the EPA nonpoint data categories are in an Excel® file on the 2014v1 NEI Supplemental data FTP site. The sections following these tables include information on key pollutants submitted by S/L/T agencies for each nonpoint source category or EIS sector.

Table 4-5: EPA-estimated emissions sources expected to be exclusively nonpoint
("Carried Forward" indicates whether EPA data were carried forward from the 2011v2 NEI.)

EPA-estimated emissions source description	Carried Forward?	EIS Sector(s) Name	Name of supporting data file or other reference
Agricultural Tilling		Agriculture – Crops & Livestock Dust	Ag Tilling v4.2.zip
Dust from livestock		Agriculture – Crops & Livestock Dust	2014V2_Dust_from_Hooves_Emission_Inventory_Tool_25Sept17.xlsx
Fertilizer Application		Agriculture – Fertilizer Application	Emissions_and_fertilizer_2011_2014_v2DRAFTrltedit.xlsx

EPA-estimated emissions source description	Carried Forward?	EIS Sector(s) Name	Name of supporting data file or other reference
Animal Husbandry		Agriculture – Livestock Waste	1_aglivestock_2014neiv2_octfinal2017.zip
Commercial Cooking		Commercial Cooking	Commercial Cooking_v1.5_2017-05-26.zip
Composting		Waste Disposal	Compost 4.1.zip
Dust from Residential, Commercial/Institutional and Road Construction		Dust – Construction Dust	Construction Dust_2016-11-11.zip
Paved and Unpaved Roads		Dust – Paved Road Dust Dust – Unpaved Road Dust	Paved Roads for 2014v2.zip Unpaved Roads for 2014v2.zip
Crop and range/pasture-land burning	X	Fires – Agricultural Field Burning	crop_residue_burning_in_2014.pdf
Residential Heating: bituminous and anthracite coal, distillate oil, kerosene, natural gas, LPG		Fuel Comb – Residential – Other	Residential Heating_v1.3_2016-11-14.zip
Residential Heating; Fireplaces, woodstoves, fireplace inserts, pellet stoves, indoor furnaces, outdoor hydronic heaters, and firelogs		Fuel Comb – Residential – Wood	RWC_Tool_v3.2.zip
Aviation Gasoline Stage 1+ Stage 2		Gas Stations	Aviation Gasoline v4.1_2016-11-11.zip
Mining and Quarrying		Industrial Processes – Mining	Mining&Quarrying_v2.3_2016-11-11.zip
Portable Gas Cans: Residential and Commercial	X	Miscellaneous Non-Industrial NEC	2014_Portable_Fuel_Containers_25nov2015.zip
Agricultural Pesticide Application		Solvent – Consumer & Commercial Solvent Use	Agricultural Pesticides_v2.1_2016-11-11.zip
Cutback Asphalt Paving -Cutback and Emulsified	X	Solvent – Consumer & Commercial Solvent Use	Asphalt Paving v2.zip
Open Burning – Brush, Residential Household Waste, Land Clearing Debris		Waste Disposal	2014 Open Burning NEI v2.zip
Human Cremation -non-mercury		Miscellaneous Non-Industrial NEC	2014v2_Human_cremation_EPA.zip
Mercury from: Dental Amalgam Production, Fluorescent Lamp Breakage		Miscellaneous Non-Industrial NEC Waste Disposal	2014 NEI v2 Mercury Nonpoint.zip

EPA-estimated emissions source description	Carried Forward?	EIS Sector(s) Name	Name of supporting data file or other reference
(Landfill emissions), Fluorescent Lamp Recycling, Human and Animal Cremation, Switches and Relays, Working Face Landfill, Thermometers and Thermostats			

Table 4-6: Emissions sources with potential nonpoint and point contribution
("Carried Forward" indicates whether EPA data were carried forward from the 2011v2 NEI.)

EPA-estimated emissions source description	Carried Forward?	EIS Sector(s) Name	Link to supporting data file
Gasoline Distribution – Stage 1: Bulk Plants, Bulk Terminals, Pipelines, Service Station Unloading, Underground Storage Tanks, Trucks in Transit;		Bulk Gasoline Terminals Gas Stations Industrial Processes – Storage and Transfer	Stage I Gasoline Distribution for NEI v2.zip Stage I PS Subtraction v1.2.zip
Industrial, Commercial/Institutional Fuel Combustion		Fuel Comb – Industrial Boilers, ICEs – All Fuels Fuel Comb – Commercial/ Institutional – All Fuels	ICI v1.6.zip
Oil and Gas Production		Industrial Processes - Oil & Gas Production	OIL_GAS_TOOL_2014_NEI_PRODUCTION_V2_2.zip
Oil and Gas Exploration		Industrial Processes - Oil & Gas Production	OIL_GAS_TOOL_2014_NEI_EXPLORATION_V2_3.zip
Publicly Owned Treatment Works	X	Waste Disposal	2014_POTW_nonpoint_emissions_23march2016.zip

EPA-estimated emissions source description	Carried Forward?	EIS Sector(s) Name	Link to supporting data file
Solvent Utilization		Solvent – Consumer & Commercial Solvent Use (except Ag Pesticides and Asphalt Paving) Solvent – Degreasing Solvent – Graphic Arts Solvent – Dry Cleaning Solvent – Graphic Arts Solvent – Industrial Surface Coating & Solvent Use Solvent – Non-Industrial Surface Coating	Solvent_Tool_v1.7.zip

4.2 Nonpoint non-combustion-related mercury sources

4.2.1 Source Description

This source category includes numerous nonpoint mercury sources from a variety of waste disposal and other activities. Table 4-7 provides the emissions sources and SCCs for nonpoint mercury. For the 2014 v1 NEI, the EPA carried forward estimates of mercury for several nonpoint emissions sources that had been newly developed for 2011. The general laboratory activities emissions (600 pounds of Hg), carried forward from 2008 for the 2011 v2 NEI were erroneously dropped in the 2014v1 but were picked up in the 2014v2 NEI selection. EPA updated the activity data to year 2014 for all other sources of non-combustion nonpoint inventory mercury in the 2014v2 NEI. Additional descriptions of the individual types of activities are provided in the source-specific sub-sections below.

Table 4-7: SCCs and emissions (lbs) comprising the nonpoint non-combustion Hg sources in the 2014 NEI

Description	SCC	Sector	SCC Description	2014v1	2014v2
Landfill working face	2620030001	Waste Disposal	Landfills; Municipal; Dumping/Crushing/Spreading of New Materials (working face)	828	763
Scrap waste: Thermostats and Thermometers	2650000000	Waste Disposal	Scrap and Waste Materials; Scrap and Waste Materials; Total: All Processes	243	241
Shredding: Switches and Relays	2650000002	Waste Disposal	Scrap and Waste Materials; Scrap and Waste Materials; Shredding	4,293	3372

Description	SCC	Sector	SCC Description	2014v1	2014v2
Human Cremation	2810060100	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Other Combustion; Cremation; Humans	2,292	2,864
Animal Cremation	2810060200	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Other Combustion; Cremation; Animals	80.2	134
Dental Amalgam Production	2850001000	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Health Services; Dental Alloy Production; Overall Process	804	923
Fluorescent Lamp Breakage	2861000000	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Fluorescent Lamp Breakage; Non-recycling Related Emissions; Total	803	1,676
Fluorescent Lamp Recycling	2861000010	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Fluorescent Lamp Breakage; Recycling Related Emissions; Total	0.2	0.6
General Laboratory Activities	2851001000	Miscellaneous Non-Industrial NEC	Miscellaneous Area Sources; Laboratories; Bench Scale Reagents; Total	N/A	635
			TOTAL	**9,343**	**10,608**

None of these categories are distinct regulatory sectors and are therefore put into the "EPA Other" category in the mercury summary provided in Table 2-12. Detailed documentation on the methods is provided in a memorandum "2014_Mercury_documentation_ 109-12-2016.pdf" provided in the supplemental documentation.

The 2011 nonpoint Hg estimates used in 2014v1 were developed in collaboration with an Eastern Regional Technical Advisory (ERTAC) workgroup set up for focus on these nonpoint emissions sources. For 2014v2 NEI, the activity data for all source categories except General Laboratory Activities (2851001000) were updated to year 2014 and then merged with S/L/T agency data as part the NEI selection hierarchy defined in Section 4.1.1. The EPA encouraged S/L/T agencies that did not use EPA's estimates or tools to improve upon these "default" 2011 methodologies (with 2014 activity data) and submit further improved data. The S/L/T data replaced the EPA estimates in the counties where S/L/T agencies provided data. Table 4-8 lists the agencies, SCCs and emissions that were submitted for these nonpoint mercury sources; the S/L/T emissions from these agencies replace EPA estimates in 2014 NEI.

Table 4-8: S/L/T-reported mercury nonpoint non-combustion emissions (lbs)

Region	Agency	S/L/T	SCC	Description	Sector	S/L/T Emissions
1	Maine Department of Environmental Protection	State	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	9

Region	Agency	S/L/T	SCC	Description	Sector	S/L/T Emissions
1	Vermont Department of Environmental Conservation	State	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	14
2	New York State Department of Environmental Conservation	State	2620030001	Landfill: Working Face	Waste Disposal	25
2	New York State Department of Environmental Conservation	State	2650000000	Scrap Waste: Thermostats and Thermometers	Waste Disposal	14
2	New York State Department of Environmental Conservation	State	2650000002	Shredding: Switches and Relays	Waste Disposal	248
2	New York State Department of Environmental Conservation	State	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	204
2	New York State Department of Environmental Conservation	State	2810060200	Animal Cremation	Miscellaneous Non-Industrial NEC	5
2	New York State Department of Environmental Conservation	State	2850001000	Dental Amalgam Production	Miscellaneous Non-Industrial NEC	33
2	New York State Department of Environmental Conservation	State	2861000000	Fluorescent Lamp Breakage	Miscellaneous Non-Industrial NEC	50
3	Maryland Department of the Environment	State	2861000000	Fluorescent Lamp Breakage	Miscellaneous Non-Industrial NEC	36
3	Virginia Department of Environmental Quality	State	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	23
5	Illinois Environmental Protection Agency	State	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	0
5	Illinois Environmental Protection Agency	State	2850001000	Dental Amalgam Production	Miscellaneous Non-Industrial NEC	61
5	Illinois Environmental Protection Agency	State	2851001000	General Laboratory Activities	Miscellaneous Non-Industrial NEC	31

Region	Agency	S/L/T	SCC	Description	Sector	S/L/T Emissions
5	Illinois Environmental Protection Agency	State	2861000000	Fluorescent Lamp Breakage	Miscellaneous Non-Industrial NEC	41
5	Illinois Environmental Protection Agency	State	2861000010	Fluorescent Lamp Recycling	Miscellaneous Non-Industrial NEC	0
5	Minnesota Pollution Control Agency	State	2850001000	Dental Amalgam Production	Miscellaneous Non-Industrial NEC	15
5	Minnesota Pollution Control Agency	State	2851001000	General Laboratory Activities	Miscellaneous Non-Industrial NEC	9
5	Minnesota Pollution Control Agency	State	2861000000	Fluorescent Lamp Breakage	Miscellaneous Non-Industrial NEC	14
5	Ohio Environmental Protection Agency	State	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	41
9	Washoe County Health District	Local	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	72
9	Washoe County Health District	Local	2810060200	Human Cremation	Miscellaneous Non-Industrial NEC	53
10	Coeur d’Alene Tribe	Tribe	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	0
10	Coeur d’Alene Tribe	Tribe	2810060200	Human Cremation	Miscellaneous Non-Industrial NEC	0
10	Idaho Department of Environmental Quality	State	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	8
10	Idaho Department of Environmental Quality	State	2810060200	Human Cremation	Miscellaneous Non-Industrial NEC	0
10	Kootenai Tribe of Idaho	Tribe	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	0
10	Kootenai Tribe of Idaho	Tribe	2810060200	Human Cremation	Miscellaneous Non-Industrial NEC	0
10	Nez Perce Tribe	Tribe	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	0

Region	Agency	S/L/T	SCC	Description	Sector	S/L/T Emissions
10	Nez Perce Tribe	Tribe	2810060200	Human Cremation	Miscellaneous Non-Industrial NEC	0
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	2810060100	Human Cremation	Miscellaneous Non-Industrial NEC	0
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	2810060200	Human Cremation	Miscellaneous Non-Industrial NEC	0
					Total	**1,007**

4.2.2 EPA-developed mercury emissions from landfills (working face)

The EPA estimated mercury emissions for landfill working face emissions. While the amount of mercury in products placed in landfills has tended to decrease in recent years, there is still a significant amount of mercury in place at landfills across the country. There are three main pathways for mercury emissions at landfills: (1) emissions from landfill gas (LFG) systems, including flare and vented systems; (2) emissions from the working face of landfills where new waste is placed; and (3) emissions from the closed, covered portions of landfills [ref 1]. Emissions from LFG systems are considered point sources and are already included in the NEI as submissions from S/L/T agencies or from the point source dataset that gap fills these landfill emissions (2014EPA_LF). Lindberg et al. (2005) [ref 1] found that emissions from the closed, covered portions of landfills are negligible and are similar to background soil emission rates. Therefore, this methodology focuses on emissions from the working face of landfills.

4.2.2.1 *Activity Data*

The U.S. EPA's Landfill Methane Outreach Program (LMOP) maintains a database of the landfills in the United States with information on the total amount of waste in place, as well as the opening and closing years of the landfill and the county where the landfill is located [ref 2]. The average number of tons of waste each landfill receives is estimated by dividing the total waste in place by the number of years the landfill has been operating. Only landfills that were open in 2014 are included in the analysis.

4.2.2.2 *Allocation Approach*

The EPA LMOP database provides data at the county level.

4.2.2.3 *Emission Factor*

Lindberg et al. (2005) [ref 1], measured mercury emissions from the working face of four landfills in Florida and determined emission factors per ton of waste placed in a landfill annually, ranging from 1-6 mg per ton of waste. The average of these emission factors is 2.5 mg/ton of waste, or 5.51×10^{-6} lbs/ton of waste.

4.2.2.4 *Example Calculation*

The New Hanover County Secure Landfill in New Hanover, NC is estimated to receive approximately 117,368 tons of waste annually.

117,368 tons of waste × 5.51 × 10^{-6} lbs Hg/ton of waste = 0.65 lbs Hg emissions

4.2.3 EPA-Developed Emissions from Thermostats

Mercury has been used in thermostats to switch on or off a heater or air conditioner based on the temperature of a room. Most of the historic production of mercury thermostats came from three corporations: Honeywell, White-Rogers, and General Electric. In 1998, these corporations formed the Thermostat Recycling Corporation (TRC), a voluntary program that attempts to collect and recycle mercury thermostats as they come out of service.

4.2.3.1 *Activity Data*

The 2002 EPA report estimated that 2-3 million thermostats came out of service in 1994 [ref 3]. A 2013 report from a consortium of environmental groups assumes that the estimate from the 2002 report remains viable, and it estimates that the TRC collects at most 8% of the retired thermostats each year [ref 4]. Therefore, using this estimate, there are approximately 2.3 million thermostats that are not recycled each year.

4.2.3.2 *Allocation Approach*

The national-level mercury emissions are apportioned to each county based on 2014 population from the U.S. Census Bureau, except for 2010 population data used for the Virgin Islands.

4.2.3.3 *Emission Factor*

The 2002 EPA report estimates that there are 3 grams of mercury per thermostat [ref 3]. Cain et al. (2007) [ref 5] estimate that 1.5% of mercury in “control devices,” including thermostats, is emitted to the air before it is disposed of at a landfill or incinerator. Therefore, the amount of mercury emitted is 0.045 grams per thermostat, or 9.9 × 10^{-5} lbs. per thermostat.

4.2.3.4 *Example Calculation*

2.3 million improperly disposed thermostats × 9.9 × 10^{-5} lbs per thermostat = 228 lbs mercury emissions

Shelby County, TN has 938,803 people, or 0.29% of the national population. The mercury emissions from thermostats in Shelby County, TN are estimated by the following:

228 lbs national mercury emissions × 0.29% = 0.672 lbs mercury emissions

4.2.4 EPA-Developed Emissions from Thermometers

Mercury thermometers have all but been phased out in the United States, with the U.S. EPA and National Institute of Standards and Technology (NIST) working to phase out mercury thermometers in industrial and laboratory settings. NIST issued a notice in 2011 that it would no longer calibrate mercury-in-glass thermometers for tracking purposes. The EPA issued a rule in 2012 that provides flexibility to use alternatives to mercury thermometers when complying with certain regulations pertaining to petroleum refining, power generation, and polychlorinated biphenyl (PCB) waste disposal [ref 6]. Furthermore, thirteen states have laws that limit the manufacture, sale, and/or distribution of mercury-containing fever thermometers [ref 6].

Nevertheless, given the historical prevalence of mercury thermometers, it is likely that a significant amount of mercury remains in thermometers in homes in the United States.

4.2.4.1 *Activity Data*

Data from the Northeast Waste Management Officials' Association (NEWMOA) Interstate Mercury Education and Reduction Clearinghouse (IMERC) database suggests that there were 713 lbs of mercury used in thermometers in 2007 [ref 6]. We assume that this value is held constant each year through 2011.

The U.S. EPA assumes that the average lifespan of a glass thermometer is 5 years, and that 5% of glass thermometers are broken each year [ref 3].[7] Therefore, if 546 lbs. of mercury are used in thermometers each year there would be an estimated 2,470 lbs of mercury remaining in thermometers in 2014 (accounting for the breakage rate each year).

NEWMOA [ref 6] estimates that during the period 2000-2006 there were 350 lbs of mercury from thermometers collected in recycling programs.

Therefore, there were 2,120 lbs (1.06 tons) of mercury available for release in 2014.

4.2.4.2 *Allocation Approach*

The national-level mercury emissions from thermometers are allocated to the county level based on 2011 population.

4.2.4.3 *Emission Factor*

Cain et al. (2007) [ref 5] estimates that 10% of mercury from thermometers is emitted to the air before disposal in a landfill, and Leopold (2002) [ref 3] estimates that 5% of thermometers are broken each year. Therefore, the emission factor is estimated to be 10 lbs of mercury emissions per ton of mercury in thermometers.

4.2.4.4 *Example Calculation*

1.06 tons of mercury in broken thermometers × 10 lbs emissions per ton = 10.6 lbs of emissions

Boise County, ID has 76,824 people, or 0.0021% of the national population. The mercury emissions from broken thermometers for Boise County are estimated by the following:

14.4 lbs national emissions × 0.0021% = 0.00022 lbs emissions

4.2.5 EPA-Developed Emissions from Switches and Relays

Switches and relays make up the largest potential source of mercury from products that intentionally contain mercury. Mercury is an excellent electrical conductor and is liquid at room temperature, making it useful in a

[7] The US EPA does not explain what happens to the remaining 75% of unbroken thermometers after the estimated 5-year lifespan, but it does suggest that recycling, such as through Fisher Scientific's thermometer trade-in program, may account for some of the remaining thermometers.

variety of products, including switches used to indicate motion or tilt, as the mercury will flow when the switch is in a certain position, completing the circuit.

While mercury switches in cars were phased out as of the 2002 model year, there are still millions of cars on the road that contain them, which are potential emissions sources when the cars are crushed and shredded during recycling at the end of their useful lives. The shredded material is then sent to an arc furnace to recycle the steel. To avoid double counting point source emissions from arc furnaces, this source category only includes an estimate of nonpoint emissions from crushing and shredding operations.

4.2.5.1 *Activity Data*

A 2011 report from the North Carolina Department of Environment and Natural Resources [ref 8] provides information on the estimated number of switches available for recovery in each state and the number of switches recovered in 2014. There were 2.6 million mercury-containing automobile switches available nationwide in 2014 and 513,877 switches collected for recycling, for a collection rate of 19.67%. These nationwide estimates are supported by similar data from the Quicksilver Caucus [ref 9]. Therefore, there were approximately 2.1 million unrecycled automotive switches in 2014.

4.2.5.2 *Allocation Approach*

The number of unrecovered switches is apportioned to each county based on the number of car recycling facilities (NAICS 423930) from the 20144 U.S. Census Bureau County Business Patterns.

4.2.5.3 *Emission Factor*

The response to comments for the 2007 EPA Significant New Use Rule on Mercury Switches (72 FR 56903), suggests that the weighted average amount of mercury in switches is 1.2 grams (0.0026 lbs). A 2001 report by Griffith et al. [ref 10] shows that 60% of mercury in switches is released at the shredding operation, while 40% is sent to arc furnaces for smelting. Therefore, the emission factor for switches is 0.00156 lbs. per switch.

4.2.5.4 *Example Calculation*

Alabama had 53,811 unrecovered vehicle switches in 2014. Baldwin County, AL has 4 car recycling facilities, which represents 2% of the facilities in the state. Therefore, that county is apportioned switches as follows:

53,811 switches in AL × 2% = 1,092.6 switches in Baldwin County, AL

Emissions are estimated as follows:

1,092.6 switches × 0.00156 lbs/switch = 1.70 lbs Hg emissions

4.2.6 EPA-Developed Emissions for Human Cremation

The cremation of individuals with mercury fillings and mercury in blood and tissues can result in mercury emissions. Cremation is becoming increasingly popular, with 40.6% of individuals being cremated in 2010, up from 33% in 2006, according to the Cremation Association of North America (CANA) [ref 11]. Note, human cremation for other pollutants was computed separately, and is discussed in Section 4.26.

4.2.6.1 *Activity Data*

The Centers for Disease Control and Prevention WONDER database contains information on the number of deaths in each county in each year for 13 different age groups through 2014 [ref 12]. Table 4-9 provides the data that we pulled from the WONDER database, which withheld data from some counties. Emission factor data is derived from the Bay Area Air Quality Management District (BAAQMD) [ref 13]. The county gaps were filled using the state totals (which included the number of deaths that were withheld at the county level). The difference between the state-level data and the sum of the reported county-level deaths was apportioned to the counties not included in the WONDER database based on their 2014 population.

The CANA data [ref 11] provides statistics on cremation rates by state as of 2010. It is assumed that the state-level cremation rate applies to all counties in the state.

Table 4-9: Comparison of age groups in the CDC WONDER database (activity data) and the BAAQMD memorandum

Age Groups in CDC WONDER Database	Age Groups in BAAQMD Memorandum	Avg. Material in Restored Teeth (g)	% of Fillings Containing Mercury	% of Mercury in Dental Amalgam
< 1 year	0-4 years*	0.000	0.0%	45.0%
1-4 years		0.160	31.6%	45.0%
5-9 years	5-14 years	0.720	31.6%	45.0%
10-14 years		0.720	31.6%	45.0%
15-19 years	15-24 years	1.070	31.6%	45.0%
20-24 years		1.070	50.0%	45.0%
25-34 years	25-34 years	2.230	50.0%	45.0%
35-44 years	35-44 years	3.290	62.5%	45.0%
45-54 years	45-54 years	4.310	62.5%	45.0%
55-64 years	55-64 years	4.320	75.0%	45.0%
65-74 years	65-74 years	3.780	75.0%	45.0%
75-84 years	75-84 years	3.650	75.0%	45.0%
85+ years	85+ years	2.960	75.0%	45.0%

* It is assumed that children under the age of 1 have no dental mercury.

4.2.6.2 *Allocation Approach*

The CDC WONDER database contains data at the county level. The CANA statistics on the cremation rate are at the state level, but it is assumed that this rate applies to all counties in the state.

4.2.6.3 *Emission Factor*

The Bay Area Air Quality Management District (BAAQMD) issued a memorandum calculating the average amount of dental mercury in each human in ten different age groups based on data from the CDC's National Health and Nutrition Examination Survey (NHANES) [ref 13]. The age groups from the BAAQMD memorandum match well with the age groups from the CDC WONDER database (Table 4-9).

The emission factors were developed using the NHANES data to determine the number of individuals in each age group with 1, 2, 3, or 4 or more restored teeth. These numbers were used along with a year-2004 published report that estimated the average mass of material in tooth restorations used in 1, 2, 3, or 4 or more teeth to determine a weighted average mass of material in tooth restorations per individual in each age group [ref 14].

The approach then accounts for the fact that not all fillings are made with mercury. According to the American Dental Association [ref 15] more than 75% of restorations before the 1970s used dental amalgam, which declined to 50% by 1991. Using these numbers, it is assumed that 50% of the filled teeth for 20-34 age group contain amalgam, 62.5% of filled teeth in the 35-49% age group, and 75% of filled teeth for people over 50. The BAAQMD memorandum was used to estimate that 31.6% of filled teeth in the 1-19 age group contain amalgam. The analysis also assumes that 45% of all amalgam-containing fillings are mercury.

The BAAQMD memorandum states that their assumptions are conservative, and could result in an overestimation of mercury emissions given that the analysis assumes that none of the mercury initially placed in the teeth is lost over time, even though data shows some loss of mercury from dental restorations, though the rate of loss is dependent on many factors, including area, age, and composition of the amalgam.

In addition to the amount of mercury in teeth, Reindl [ref 16] estimates mercury emissions from blood and tissues (but not dental amalgam) from humans at 0.000132 lbs./cremation, assuming an average weight at cremation of 176 lbs.

4.2.6.4 *Example Calculations*

Estimating mercury in teeth:

There were 112 deaths in the 75-84 age group in Autauga County, AL in 2014. The emission factor for that age group is 1.2319 grams of mercury, or 0.0027 lbs., per cremated human. Alabama has a cremation rate of 23.1%. To calculate the mercury emissions from this age group, these numbers are multiplied together:

112 deaths in the 75-84 year age group × 23.1% cremation rate × 0.0027 lbs. Hg/cremation

= 0.069 lbs. Hg emissions for the 75-84 year age group in Autauga County, AL

Estimating mercury in blood and tissues:

112 deaths in the 75-84 year age group × 23.1% cremation rate × 0.000132 lbs. Hg/cremation

= 0.00342 lbs. Hg emissions for the 75-84 year age group in Autauga County, AL

Total mercury emissions:

0.069 + 0.00342 = 0.0733 lbs. Hg emissions

This is repeated for each age group in Table 4-9 in each county.

4.2.7 EPA-Developed Emissions for Animal Cremation

Animal tissues contain mercury, similar to humans. A 2012 survey from the Pet Loss Professionals Alliance [ref 17] found that 99% of deceased pets are cremated, with the remaining 1% receiving burial. Therefore, mercury from animal tissues through cremation can be a source of nonpoint mercury emissions.

4.2.7.1 *Activity Data*

The PLPA survey estimates that there were 1,840,965 pet cremations in 2012. In addition, the Humane Society of the United States [ref 18) estimates that there are 2,700,000 dogs and cats euthanized in animal shelters each year. It is assumed that these shelter animals are cremated. Therefore, there are a total of approximately 4,540,965 animal creations each year. Note that this estimate does not double count the number of animal cremations, because the PLPA study counts the number of cremations of pets—i.e. animals that are owned by people—whereas the Humane Society estimates are for animals in shelters that were not adopted.

The population of cats and dogs is approximately 52.5% cats and 48.5% dogs [ref 18]. The average weight of a domestic cat is approximately 12.5 lbs [ref 19]. The average weight of a dog is difficult to determine due to large differences in breeds, but one estimate suggests it is 35 lbs. [ref 20]. Therefore, the total weight of cremated animals is approximately 53,441 tons.

4.2.7.2 *Allocation Approach*

The national-level mercury emissions from animal cremation are allocated to the county level based on 2014 human population.

4.2.7.3 *Emission Factor*

Emission factors for mercury emissions from animal cremations are not available from the literature. Reindl [ref 16) estimates mercury emissions from blood and tissues (but not dental amalgam) from humans at 0.0015 lbs/ton. This emission factor appears to be the most appropriate available emission factor for animals, given that it does not include dental amalgam. This approach assumes that pets have the same exposure, adsorption rates, and accumulation of Hg as humans, on average.

4.2.7.4 *Example Calculation*

Total mercury emissions from animal cremations:

$$53{,}441 \text{ tons cremated animals} \times 0.0015 \text{ lbs/ton} = 80.2 \text{ lbs mercury emissions}$$

Walla Walla County, Washington has 59,844 people, or 0.019% of the national population. The mercury emissions from animal cremations in Walla Walla are estimated by the following:

$$80.2 \text{ lbs national mercury emissions} \times 0.019\% = 0.015 \text{ lbs mercury emissions}$$

4.2.8 EPA-Developed Emissions for Dental Amalgam Production

Dental amalgam is used to fill cavities in teeth, and it is composed of approximately 45% mercury [ref 13]. The use of mercury in dental amalgam is declining, however, due to the increased popularity of composite fillings for teeth [ref 21]. Nevertheless, there is still a small amount of mercury emissions from dental amalgam in restored teeth. There are two potential sources of mercury emissions from dental amalgam: emissions from the preparation of amalgam in dental offices and a small amount of emissions directly from restored teeth.

4.2.8.1 *Activity Data*

The amount of amalgam prepared in dental offices was estimated using NEWMOA's IMERC database [ref 22], which estimates that 15.97 tons (31,940 lbs) of mercury in dental amalgam were used in 2013.

The amount of mercury emissions from restored teeth was estimated using data from the National Institutes of Health's National Institute of Dental and Craniofacial Research [ref 23], which provides estimates of the average number of filled teeth per person in three different age brackets: 20-34 years, 35-49 years, and 50-64 years. The number of filled teeth for other age groups was estimated using the CDC National Health and Nutrition Examination Survey (NHANES). Table 4-10 lists the average number of filled teeth per person by age group.

Table 4-10: Average number of filled teeth per person and percentage of fillings containing mercury by age group

Age Group	Average Number of Filled Teeth Per Person	Percentage of Fillings Containing Mercury
0-5	0.44	31.6
5-19	1.23	31.6
20-34	4.61	50.0
35-49	7.78	62.5
50-64	9.20	75.0
65+	6.47	75.0

According to the American Dental Association [ref 15] more than 75% of restorations before the 1970s used amalgam, which declined to 50% by 1991. Using these numbers, it is assumed that 50% of the filled teeth for 20-34 age group contain amalgam, 62.5% of filled teeth in the 35-49% age group, and 75% of filled teeth for people over 50. The BAAQMD memorandum was used to estimate that 31.6% of filled teeth in the 1-19 age group contain amalgam.

4.2.8.2 *Allocation Approach*

The emissions from dental office preparations were allocated to the county level based on 2014 population.

The emissions from filled teeth were allocated to each county by multiplying the county population by the proportion of the national population in each age group (from 2014 U.S. Census Bureau data, except 2010 vintage for Virgin Islands), the average number of filled teeth per person, and the percentage of fillings containing mercury (Table 4-9). The emissions were then added across age groups.

4.2.8.3 *Emission Factor*

U.S. EPA [ref 24] estimates that 2% of mercury used in dental offices is emitted to the air.

Richardson et al. [ref 25] estimate emissions from filled teeth of approximately 0.3 µg/day of mercury emissions per filled tooth, or 2.4×10^{-7} lbs. per year per filled tooth.

4.2.8.4 *Example Calculation*

<u>Emissions from dental office preparations:</u>

$$31{,}940 \text{ lbs Hg} \times 2\% = 638.8 \text{ lbs emissions}$$

Orleans Parish, LA has 384,320 people, representing 0.121% of the national population. The mercury emissions from dental office preparations in Orleans Parish are estimated by the following:

$$638.8 \text{ lbs national emissions} \times 0.121\% = 0.77 \text{ lbs Hg mercury emissions from dental offices}$$

Emissions from restored teeth:

Nationally, 14.5% of the population is in the 65+ age group. This age group has an average of 6.47 fillings per person, and 75% of their fillings contain mercury. The emissions from restored teeth in Orleans Parish, LA are estimated by the following:

$$384{,}320 \text{ people} \times 14.5\% \text{ in 65+ age bracket} \times 6.47 \text{ fillings per person} \times 75\% \text{ of fillings with mercury} \times 2.4 \times 10^{-7} \text{ lbs per year per filled tooth}$$

$$= 0.065 \text{ lbs mercury in the 65+ age bracket in Orleans Parish}$$

This is repeated for each age group in Table 4-10 for each county.

4.2.9 EPA-Developed Emissions for Fluorescent Lamp Breakage (not recycled)

Fluorescent lights are a potentially significant source of mercury emissions. Although each lamp contains only a small amount of mercury, which has been decreasing in recent years, the increased demand for fluorescent lamps, particularly compact fluorescents, driven partly by the phase out of many types of incandescent bulbs from the Energy Independence and Security Act of 2007 (PL 110-140 § 321), could lead to increases in mercury emissions.

4.2.9.1 *Activity Data*

Data from a Freedonia Group Industry Study on the U.S. lamp market was used to estimate that 1.4 billion mercury containing lamps, including CFLs and high impact discharge (HID) lamps, were discarded or recycled in 2014. Bulb sales for 2002, 2007, 2012 and projections for 2017 were obtained from Freedonia; sales for all other years were calculated by extrapolating data. Average rated life (hrs) of lamp types were used to calculate lifetimes (yrs), assuming that CFLs are on for 4 hours per day and all other fluorescents and HIDs are on for 8 hours per day (Buildings.com, 2008) [ref 26].

According to a 2010 study by Silveira and Chang [ref 27], the recycling rate for mercury containing lamps in the U.S. is 23%. Taking into account recycling, this suggests that there were approximately 1.1 billion mercury-containing lamps discarded at landfills in 2014.

4.2.9.2 *Allocation Approach*

The national-level mercury emissions from fluorescent lamp breakage are allocated to each county based on 2014 population.

4.2.9.3 *Emission Factor*

Cain et. al [ref 28] provides the most comprehensive materials flow analysis of mercury intentionally used in products. Their analysis estimates that 10% of all mercury used in fluorescent light bulbs is eventually released to the atmosphere after production and before disposal, with the majority being released during transport to the disposal facility.

The average amount of mercury in a CFL has been studied extensively, with the amount of mercury in each CFL commonly reported as 1.27–4.0 mg (2.63 mg average, Table 4-11). Linear fluorescent bulbs contain more mercury than CFLs, with a range of 8.3 to 12 mg per bulb (10.15 average, Table 4-12). Data from the USGS suggests that there is an average of 17 mg of mercury per HID bulb [ref 29].

Table 4-11: Mercury used in CFLs (mg/bulb) as determined by three different studies

Study	Average Amount of Mercury per CFL (mg)
Li and Jin [ref 30]	1.27
Katers et al. [ref 31]	4.00
Singhvi et al. [ref 32]	2.63
Average	**2.63**

Table 4-12: Mercury used in linear fluorescent bulbs (mg/bulb) as determined by two different studies

Study	Average Amount of Mercury per Linear Fluorescent Bulb (mg)
Aucott et al. [ref 33]	12.0
NEMA [ref 34]	8.3
Average	**10.2**

Therefore, the emission factor for CFLs would be:

2.63 mg per CFL × 10% = 0.263 mg of emissions per CFL

The emission factor for linear bulbs would be:

10.15 mg per linear bulb ×10% = 1.015 mg per linear bulb

The emission factor for HID bulbs would be:

17 mg per HID bulb × 10% = 1.7 mg per HID bulb

4.2.9.4 *Example Calculation*

Emissions from CFLs:

519 million discarded bulbs × 0.263 mg per CFL

= 136.4 million mg mercury emissions from CFLs

Emissions from linear bulbs:

462 million discarded bulbs × 1.015 mg per bulb

= 472.3 million mg mercury emissions from linear bulbs

Emissions from HID bulbs:

112 million discarded bulbs × 1.7 mg per bulb

= 190.3 million mg mercury emissions from HID bulbs

Total mercury emission from breakage of mercury-containing bulbs:

136.4 million mg + 472.3 million mg + 190.3 million mg = 799 million mg

= 799 kg

$$= 1{,}758 \text{ lbs mercury emissions}$$

Weston County, WY was estimated to have 7,201 people in 2014, or 0.0023% of the national population. The emissions for Weston County are estimated as follows:

$$1{,}758 \text{ lbs national Hg emissions} \times 0.0023\% \text{ of national population} = 0.04 \text{ lb. Hg emissions}$$

4.2.10 EPA-Developed Emissions for Fluorescent Lamp Breakage (recycling)

In addition to emissions of mercury from the breakage of fluorescent light bulbs (SCC 2861000000), there are a small amount of emissions from recycling fluorescent bulbs.

4.2.10.1 *Activity Data*

The activity data were previously described in Section 4.2.9.1. Considering recycling rates, this suggests that there were approximately 327 million mercury-containing lamps recycled in 2014.

4.2.10.2 *Allocation Approach*

The national-level mercury emissions from the recycling of mercury-containing lamps are allocated to each county based on 2014 population.

4.2.10.3 *Emission Factor*

The U.S. EPA [ref 24] has estimated an emission factor from mercury-containing bulb recycling of 0.00088 mg/lamp (1.9×10^{-9} lb./lamp).

4.2.10.4 *Example Calculation*

Emissions from recycling of mercury-containing bulbs:

$$327 \text{ million bulbs recycled} \times 1.9 \times 10^{-9} \text{ lb/lamp} = 0.6 \text{ lbs mercury emissions}$$

Cumberland County, ME has a population of 281,797 people, or 0.09% of the national population. The emissions from the recycling of mercury-containing bulbs in Cumberland County, ME were estimated by the following:

$$0.6 \text{ lbs mercury emissions} \times 0.09\% = 0.00057 \text{ lbs mercury emissions}$$

4.2.11 EPA-Developed Emissions for General Laboratory Activities

Documentation for previous versions of the NEI have cited personal communications with USGS staff for estimates of the amount of mercury used in general laboratory activities. In discussions with Robert Virta of the USGS [ref 35], it was determined that because the USGS stopped conducting its survey of the end uses of mercury in the economy in 2002 it would be impossible to state with any confidence an estimate of the amount of mercury used in general laboratory activities in 2014. The estimate from the 2008 NEI was pulled forward for the 2011 NEI. Further literature searches again revealed no data that could be used to estimate mercury emissions for this source category; therefore, the estimate from the 2008 NEI was pulled forward for the 2014 NEI.

This category accounts for approximately 600 pounds of mercury of EPA-estimated mercury; however, as seen in Table 4-8, Minnesota and Illinois reported 40 cumulative pounds of mercury for this source and the 2008-based EPA estimates for the remaining states fill out the rest of the emissions in the 2014 v2 NEI.

4.2.12 Agency-reported emissions

Agency-reported emissions for all non-combustion nonpoint mercury sources were summarized in Table 4-8 in Section 4.2.1. Eight states, 1 local and 3 tribal agencies reported one or more of these nonpoint mercury sources for 2014 NEI.

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4.3 Agriculture – Crops & Livestock Dust

4.3.1 Sector description

Cropland dust and dust from animal hooves are significant sources of atmospheric dust, both fine and coarse particulate matter (PM2.5 and PM10, respectively). The SCCs that are in this sector for the 2014 NEI are provided in Table 4-13. The SCC level 1 description is "Miscellaneous Area Sources" for all SCCs. The EPA estimates emissions for fugitive dust emissions from agricultural tilling (SCC 2801000003) and new for 2014v2, dust kicked up by hooves (SCC 2805001000), highlighted in the table; the methodology is described in Section 4.3.3.

Table 4-13: SCCs used in the 2014 NEI for the Agriculture – Crops & Livestock Dust sector

SCC	SCC Level 2	SCC Level 3	SCC Level 4
2801000000	Agriculture Production - Crops	Agriculture - Crops	Total
2801000003	Agriculture Production - Crops	Agriculture - Crops	Tilling
2801000005	Agriculture Production - Crops	Agriculture - Crops	Harvesting
2801000007	Agriculture Production - Crops	Agriculture - Crops	Loading
2801000008	Agriculture Production - Crops	Agriculture - Crops	Transport
2801600000	Agriculture Production - Crops	Country Grain Elevators	Total
2805001000	Agriculture Production - Livestock	Beef cattle - finishing operations on feedlots (drylots)	Dust Kicked-up by Hooves

4.3.2 Sources of data

The agricultural crops and livestock dust sector includes data from S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-14 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-14: Percentage of total PM Agricultural Tilling emissions submitted by reporting agency

Region	Agency	S/L/T	PM_{10}	$PM_{2.5}$
1	New Hampshire Department of Environmental Services	State	81	81
2	New Jersey Department of Environment Protection	State	44	46
3	Maryland Department of the Environment	State	87	90
4	Georgia Department of Natural Resources	State	0	0
4	Metro Public Health of Nashville/Davidson County	Local	60	
5	Illinois Environmental Protection Agency	State	96	97
7	Iowa Department of Natural Resources	State	72	78
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	100	100
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	Tribe	100	100
8	Utah Division of Air Quality	State	4	3
9	California Air Resources Board	State	34	28
10	Coeur d'Alene Tribe	Tribe	100	100
10	Idaho Department of Environmental Quality	State	83	82
10	Kootenai Tribe of Idaho	Tribe	100	100

Region	Agency	S/L/T	PM_{10}	$PM_{2.5}$
10	Nez Perce Tribe	Tribe	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100	100
10	Washington State Department of Ecology	State	90	89

4.3.3 EPA-developed emissions for agriculture, crops and livestock dust

4.3.3.1 *Source Category Description*

Agricultural Tilling

Fugitive dust emissions from agricultural tilling (SCC=2801000003) include the airborne soil particulate emissions produced during the preparation of agricultural lands for planting. Fugitive dust emissions from agricultural tilling were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there is no condensable PM (PM-CON) emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL. Particulate emissions from agricultural tilling were computed by multiplying a crop-specific emissions factor by an activity factor, as described below.

Dust Kicked up by Hooves

While hoof emissions are primarily considered to be emissions made by cattle, swine and sheep, poultry emissions of dust were also examined. Fugitive dust emissions from hooves were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there are no PM-CON emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL. There did not exist separate animal-specific SCCs for dust kicked up by hooves (or feet); therefore, all animals were aggregated to the one available SCC (for "Beef cattle", SCC 2805001000) for 2014v2. We decided to wait until the 2017 NEI cycle to separate out the dust kicked up by hooves/feet emissions by animal type. For 2014v2 purposes this SCC represents the total for all livestock. In 2017 we hope to utilize a new approach to help with consistency in SCC descriptions and will separate by animal type at that time.

4.3.3.2 *Emission Factor Equation*

Agricultural Tilling

The county-level emission factors for agricultural tilling (in lbs per acre) are specific to the crop type and tilling method and were calculated using the following equation [ref 1, ref 2]:

$$EF = 4.8 \times k \times s^{0.6} \times p_{crop,tilling\ type}$$

where:

k = dimensionless particle size multiplier (PM_{10} = 0.21; $PM_{2.5}$ = 0.042),
s = silt content of surface soil (%), and
p = number of passes or tillings in a year for a given crop and tilling method.

The U.S. Department of Agriculture (USDA) and the National Cooperative Soil Survey define silt content of surface soil as the percentage of particles (mass basis) of diameter smaller than 50 micrometers (µm) found in the surface soil.[8] The soil sample data used to estimate county-level, average silt content values are from the National Cooperative Soil Survey Microsoft® Access® Soil Characterization Database [ref 3]. This database contains the most commonly requested data from the National Cooperative Soil Survey Laboratories including data from the Kellogg Soil Survey Laboratory and cooperating universities.

The EPA applied specific selection criteria to the database to ensure that all samples are comparable and relevant to this analysis. The selection criteria included selecting only samples taken inside the United States with a preparation code of S and a horizon top of zero centimeters or a master horizon of A or O. A preparation code of S signifies that the sample is the air-dried whole soil passing through a 3-inch sieve and a horizon top of zero or master horizon of A or O ensures that the sample is taken at the surface.

In some cases, the sample metadata did not indicate a county, but included latitude and longitude coordinates. In these cases, the state and county information were reverse geocoded from the coordinates and added to the sample entry in the database.

After gap-filling the missing state and county information, the average silt content for a county was calculated by summing the total silt content of all the samples in the county and dividing by the number of samples in the county. For counties without samples, the average silt content was calculated by summing the total silt content of soil samples in neighboring counties and dividing by the number of samples in the neighboring counties. If neighboring counties also lacked sample data, then the county was assigned the average silt value of soil samples within the state.

Dust Kicked up by Hooves

Dust emission factors were obtained from a variety of different literature articles [ref 4 through ref 23] for each livestock type. From the literature, calculations were done to obtain the emission factor for each pollutant in the desired form. No references for $PM_{2.5}$ emission factors were found in the extensive literature search for Beef Cattle. To complete $PM_{2.5}$ for this tool, the Dairy Cattle PM_{10} to $PM_{2.5}$ ratio of 4.81118266481148 from this tool was used and is based on ratios in the PM Augmentation tool. The general methodology for computing emission factors is provided below:

1. Determine if study calculated emission factors (EF) for pollutants
2. If the study did calculate EFs, then convert (if necessary) to ton/year/1000 head
3. If the study did not calculate EF, calculate EF if possible
4. To calculate the EF, the following equation* is used:

EF (ton/year/1000 head) = Emission rate (ton/year) / Animal Units

*Adapted from Equation 2-1 from the NRC's Scientific Basis for Estimating Air Emissions from Animal Feeding Operations: Interim Report (2002)

5. Make sure the emission rate (typically given) is in the correct units (ton/year)
6. Calculate the animal units using the following equation from the Wisconsin Department of Natural Resources:

AU = Equivalent Factor * Number of Animals

[8] Note that this is different than the U.S. Environmental Protection Agency's definition that includes all particles (mass basis) of diameter smaller than 75 micrometers.

Where the equivalent factor is obtained from Table 4-15 and the number of animals is obtained from the study.

Note: In some cases, the weight of the animals is also necessary to obtain the equivalent factor.

7. Convert the AU to number of animals, assuming 1 AU = 500 kg
8. Calculate the emission factor in tons/year/head
9. Multiply calculated emission factor by 1000 to get the tons/year/1000 head

Table 4-15: Animal Units Equivalent Factors

Animal type	Specification	AU Equivalent Factor
Cattle	Dairy/Beef Calves (under 400lbs)	0.20
Dairy Cattle	Milking & Dry Cows	1.40
Dairy Cattle	Heifers (800-1200 lbs)	1.10
Dairy Cattle	Heifers (400 – 800 lbs)	0.60
Beef Cattle	Steers or Cows (400 lbs to market)	1.00
Beef Cattle	Bulls	1.40
Cattle	Veal Calves	0.50
Swine	Pigs (up to 55 lbs)	0.10
Swine	Pigs (55 lbs to market)	0.40
Swine	Sows	0.40
Swine	Boars	0.50
Chicken	Layers – non-liquid manure system	0.01
Chicken	Broilers/pullets – non-liquid manure system	0.005
Chicken	Bird – liquid manure system	0.033
Ducks	Liquid manure system	0.2
Ducks	Non-liquid manure system	0.01
Turkeys	Turkey	0.018
Sheep	Sheep	0.1
Horses	Horses	2

4.3.3.3 *Activity data*

Agricultural Tilling

The basis of agricultural tilling emission estimates is the number of acres of crops tilled in each county by crop type and tillage type. These data were estimated based on data from the USDA *2012 Census of Agriculture* [ref 24]. The USDA Census of Agriculture reports acres harvested for a given crop at the county level, but does not provide tilling data for each crop type at the county level. To calculate acres harvested per tilling type for each crop, the breakdown of tilling types (conservation, no-till, and conventional) at the county-level was applied to the acres harvested for each crop type at the county level. The county-level tilling type data for 2012 was provided by the USDA upon request [ref 25].

Several counties had data for acres harvested by crop type from the USDA Census of Agriculture, but did not have acres for each tilling type. For these counties, we used the state percentages of conservation, no-till, and conventional tilling as a surrogate for county data.

The USDA Census of Agriculture redacts some county-level data to avoid disclosing data for individual farms. Missing county-level data for acres harvested by crop type and tilling type were calculated using the difference between the state and national level reported data and the sum of the county-level data by state.

Tilling data for permanent pasture followed a different methodology. Conventional tilling data were available for the state of Utah [ref 26]. A ratio of the conventional tilling acres to the total acres of permanent pasture for Utah was developed (0.0023) and applied to the total acreage data for permanent pasture from the *2012 Census of Agriculture* to determine the number of conventional tilled permanent pasture acres by county in other states. It is assumed that the remainder of the permanent pasture acres is not tilled, so the remaining distribution of permanent pasture acres was distributed to no till acres and conservation tilling acres were left as zero.

Table 4-16 shows the number of passes or tillings in a year for each crop for conservation use, no-till and conventional use [ref 27]. Mulch till and ridge till tillage systems are classified as conservation use, while 0 to 15 percent residue and 15 to 30 percent residue tillage systems are classified as conventional use.

Table 4-16: Number of passes or tillings per year in 2014v2 NEI

Crop	Conservation Use	No-Till	Conventional Use
Barley	3	3	5
Beans	3	3	3
Canola	3	3	3
Corn	1	0	2
Cotton	5	5	8
Cover	0	0	0
Fallow	1	1	1
Fall-seeded/Winter Wheat	3	3	5
Forage	3	3	3
Hay	3	3	3
Oats	3	3	5
Peanuts	3	3	3
Peas	3	3	3
Permanent Pasture	0	0	1
Potatoes	3	3	3
Rice	5	5	5
Rye	3	3	5
Sorghum	1	1	6
Soybeans	1	0	2
Spring Wheat	1	1	4
Sugarbeets	3	3	3
Sugarcane	3	3	3
Sunflowers	3	3	3
Tobacco	3	3	3

A summary of national-level acres tilled in 2012 for each tilling type are presented in Table 4-17.

Table 4-17: Acres tilled by tillage type, in 2012

Tillage system	National (millions of) acres tilled in 2012
No-Till	658.07
Conservation	162.19
Conventional	273.16
Total	**1,093.42**

Agricultural Tilling: New in 2014v2

The *2012 Census of Agriculture* does not include information about cover crops, so emissions from tilling for cover crops were not estimated for the 2014 NEI. Review from a couple of agencies led to changes in methodology for this sector; no-till passes were increased for all counties, which resulted in a reduction in EPA-estimated PM emissions.

In 2014v1, the number of passes or tillings per year for corn, cover and soybeans were greater, as shown in Table 4-18.

Table 4-18: Number of passes or tillings per year in 2014v1 NEI, replaced in 2014v2 with new values

Crop	Conservation Use	No-Till	Conventional Use
Corn	2	2	6
Cover	1	1	1
Soybeans	1	1	6

Dust Kicked up by Hooves

The United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) Quick Stats program was utilized to obtain the activity data. The 2014 USDA Survey was used to obtain the livestock count for as many counties as possible across the United States. Because the survey did not cover the entire country, the USDA 2012 Census was used to fill in much of the remaining entities. However, the 2012 Census and the 2014 Survey were not spatially complete when combined, so it was necessary to calculate the missing county data using the following methods:

For Swine and Poultry: For missing counties, the total value for the counties present is added up and then subtracted from the statewide reported value. This will result in the missing number of animals from the state. From there, the number of counties reporting (D – Did not report) are counted and the total missing animals is divided by the number of counties that did not report. This resulting number is then allocated to each county that reported a (D) value. The counties skipped in the survey are given a value of 0.

Example:

County 1: 20
County 2: 45
County 3: (D)
County 4: 5
County 5: (D)
State total: 100

1. Calculate sum of all counties: 20 + 45 + 5 = 70

2. Calculate number of cattle missing from counties: 100 – 70 = 30
3. Since 2 states did not report values: 30/2 =15
4. Allocate 15 animals to County 3 and 15 animals to County 5

Therefore, the county animal totals are as follows:

County 1: 20
County 2: 45
County 3: 15
County 4: 5
County 5: 15

For Cattle: Following the work of Carnegie Mellon University (CMU), the total beef cattle is equal to the total cattle (including calves) minus the dairy cattle. To get the correct number of total cattle, a method similar to what is described above is used. For the counties missing data, the total value for the counties present is added up and then subtracted from the statewide reported value. This number is then divided by the total number of states that did not report the total number of cattle. The dairy cattle missing in each county are calculated using the formula:

Dairy Cattle = # Dairy Cattle missing in county*(Total Cattle (incl. calves) in county/sum of Total Cattle in all counties missing data)

Then, finally, the beef cattle can be calculated using the formula:

Beef Cattle = Total # Cattle - # Dairy Cattle

Example:

County	Total Cattle (including calves)	Beef Cattle	Dairy Cattle
1	30		20
2	100		30
3	20		(D)
4	(D)		(D)
5	(D)		10

Total State Cattle: 250
Total Dairy Cattle: 100

1. Get total cattle: 30+100+20 = 150
   Total missing cattle: 100, therefore 50 cattle go to each county that did not report

County	Total Cattle (including calves)	Beef Cattle	Dairy Cattle
1	30		20
2	100		30
3	20		(D)
4	**50**		(D)
5	**50**		10

2. Get total dairy cattle:
   Missing number of dairy cattle: 100 – 20 – 30 – 10 = 40
   Total number of cattle in counties missing dairy: 20 + 50 = 70

dairy/county = 40* (total number of cattle in missing county/70)
Therefore, the number of dairy cattle in:
County 3 = 40*(20/70) = ~11
County 4 = 40*(50/70) = ~29

County	Total Cattle (including calves)	Beef Cattle	Dairy Cattle
1	30		20
2	100		30
3	20		**11**
4	**50**		**29**
5	**50**		10

3. Calculate total beef by subtracting dairy cattle from total cattle.*

County	Total Cattle (including calves)	Beef Cattle	Dairy Cattle
1	30	10	20
2	100	70	30
3	20	9	**11**
4	**50**	21	**29**
5	**50**	40	10
Sum	**250**	**150**	**100**

*It is important to note that the total beef cattle obtained from the US Census is the actual total for beef cattle in each county. However, the procedures listed above were followed for the census data when data wasn't given.

4.3.3.4 *Example calculation*

<u>Agricultural Tilling</u>

The following equation was used to determine the emissions from agricultural tilling for 2012 [ref 1, ref 2]. The county-level activity data are the acres of land tilled for a given crop and tilling type. The equation is adjusted to estimate PM_{10} and $PM_{2.5}$ emissions using the following parameters: a particle size multiplier, the silt content of the surface soil, the number of tillings per year for a given crop and tilling type, and the acres of land tilled for a given crop and tilling type.

$$E = \Sigma c \times k \times s^{0.6} \times p_{crop,tilling\ type} \times a_{crop,tilling\ type}$$

where: *E* = PM10-FIL or PM25-FIL emissions

c = constant 4.8 lbs/acre-pass
k = dimensionless particle size multiplier (PM_{10}=0.21; $PM_{2.5}$=0.042)
s = percent silt content of surface soil, defined as the mass fraction of particles smaller than 50 µm diameter found in surface soil
p = number of passes or tillings in a year
a = acres of land tilled (activity data)

<u>Dust Kicked up by Hooves</u>

A general method to calculate the emissions per county for a given pollutant can be calculated by multiplying the emission factor for the given livestock type by the animal activity in each county. However, some manipulation is necessary to obtain the desired result.

To calculate the dust emissions due to hooves, the first step is to divide the emission factor (ton per year per 1000 head) by 1000. The resulting emission factor is then multiplied by the number of animals (head) in the region to get the emission (tons per year).

If the emission factor of PM2.5 emitted by beef cattle is approximately 10 ton per year per 1000 head and the farm is known to have 100 beef cattle, then the emission of this pollutant by the farm can be calculated using the following procedure:

1. Convert the emission factor from tons per year per 1000 head to tons per year per head

   10 tons per year per 1000 head / 1000 = 10/1000 tons per year per head
   = .01 tons per year per head

2. Calculate the emissions (tons/year):

   Emissions = Emission Factor*Number of head
   Emissions = 0.01 tons per year per head*100 head = 1 ton per year

4.3.3.5 *Controls*

No controls were accounted for in the emission estimations.

4.3.3.6 *Changes from 2011 Methodology: Agricultural Tilling*

The 2008 emission estimates were based on data from the Conservation Technology Information Center's *National Crop Residue Management Survey* [ref 28]. This survey was discontinued in 2008; therefore, in 2014 the agricultural tilling emissions were created by applying growth factors to the 2008 agricultural tilling dataset. These growth factors were derived from state- level USDA statistics on various crop types.

The 2014 agricultural tilling emissions were estimated using data on harvested acres and tillage type obtained from the USDA's *2012 Census of Agriculture*. This included data on fallow and permanent pasture that were previously estimated using a top-down allocation approach based on farm numbers.

4.3.3.7 *Puerto Rico and US Virgin Islands Emissions Calculations: Agricultural Tilling*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the U.S. Virgin Islands, emissions are based on two proxy counties in Florida: Broward County (FIPS state county code = 12011) for Puerto Rico and Monroe County (FIPS = 12087) for the U.S. Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and U.S. Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.3.4 Summary of quality assurance methods

Metals for this sector were submitted by only one agency. The emissions were estimated using ratios of metals to $PM_{2.5}$. While these ratios were very small numbers; the resulting calculations gave very large amounts of metals. For example, the state-submitted emissions of Hg from agricultural tilling (for the one agency) was nearly 10 percent of the national mercury inventory. Because these data were not available for other states and because the resulting high emissions seemed extremely suspect, we did not include the state-submitted metals in the NEI.

4.3.5 References for agricultural crops & livestock dust

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4.4 Agriculture – Fertilizer Application

4.4.1 Sector description

Fertilizer in this category refers to any nitrogen-based compound, or mixture containing such a compound, that is applied to land to improve plant fitness. The SCCs that compose this sector in 2014 NEI are provided in Table 4-19. The SCC level 1 description is “Miscellaneous Area Sources” for all SCCs. EPA-estimated emissions are for SCC 2801700099 and discussed in Section 4.4.3.

Table 4-19: Source categories for agricultural Fertilizer Application

SCC	SCC Level 2	SCC Level 3	SCC Level 4
2801700001	Agriculture Production - Crops	Fertilizer Application	Anhydrous Ammonia
2801700002	Agriculture Production - Crops	Fertilizer Application	Aqueous Ammonia
2801700003	Agriculture Production - Crops	Fertilizer Application	Nitrogen Solutions
2801700004	Agriculture Production - Crops	Fertilizer Application	Urea
2801700005	Agriculture Production - Crops	Fertilizer Application	Ammonium Nitrate
2801700006	Agriculture Production - Crops	Fertilizer Application	Ammonium Sulfate
2801700007	Agriculture Production - Crops	Fertilizer Application	Ammonium Thiosulfate
2801700010	Agriculture Production - Crops	Fertilizer Application	N-P-K (multi-grade nutrient fertilizers)
2801700011	Agriculture Production - Crops	Fertilizer Application	Calcium Ammonium Nitrate
2801700012	Agriculture Production - Crops	Fertilizer Application	Potassium Nitrate
2801700013	Agriculture Production - Crops	Fertilizer Application	Diammonium Phosphate
2801700014	Agriculture Production - Crops	Fertilizer Application	Monoammonium Phosphate
2801700015	Agriculture Production - Crops	Fertilizer Application	Liquid Ammonium Polyphosphate
2801700099	Agriculture Production - Crops	Fertilizer Application	Miscellaneous Fertilizers

4.4.2 Sources of data

The agricultural fertilizer application sector includes data from the S/L/T agencies and the default EPA-generated agricultural fertilizer emissions. The agencies listed in Table 4-20 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (totals of 100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-20: Percentage of total fertilizer application NH_3 emissions submitted by reporting agency

Region	Agency	S/L/T	Ammonia
4	Georgia Department of Natural Resources	State	0
5	Illinois Environmental Protection Agency	State	100
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	100
9	California Air Resources Board	State	57
10	Idaho Department of Environmental Quality	State	100
10	Coeur d'Alene Tribe	Tribe	100
10	Kootenai Tribe of Idaho	Tribe	100
10	Nez Perce Tribe	Tribe	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100

4.4.3 EPA-developed emissions for fertilizer application: revised for 2014v2

The approach to calculating emissions from this sector in 2014 is a completely new methodology. For 2014, the bidirectional version of CMAQ (v5.0.2) [ref 1] and the Fertilizer Emissions Scenario Tool for CMAQ FEST-C (v1.2) [ref 2] were used to estimate ammonia (NH_3) emissions from agricultural soils. These estimates were then loaded into EIS for use in the 2014v2 NEI. The approach to estimate 2014v2 fertilizer emissions consists of these steps:

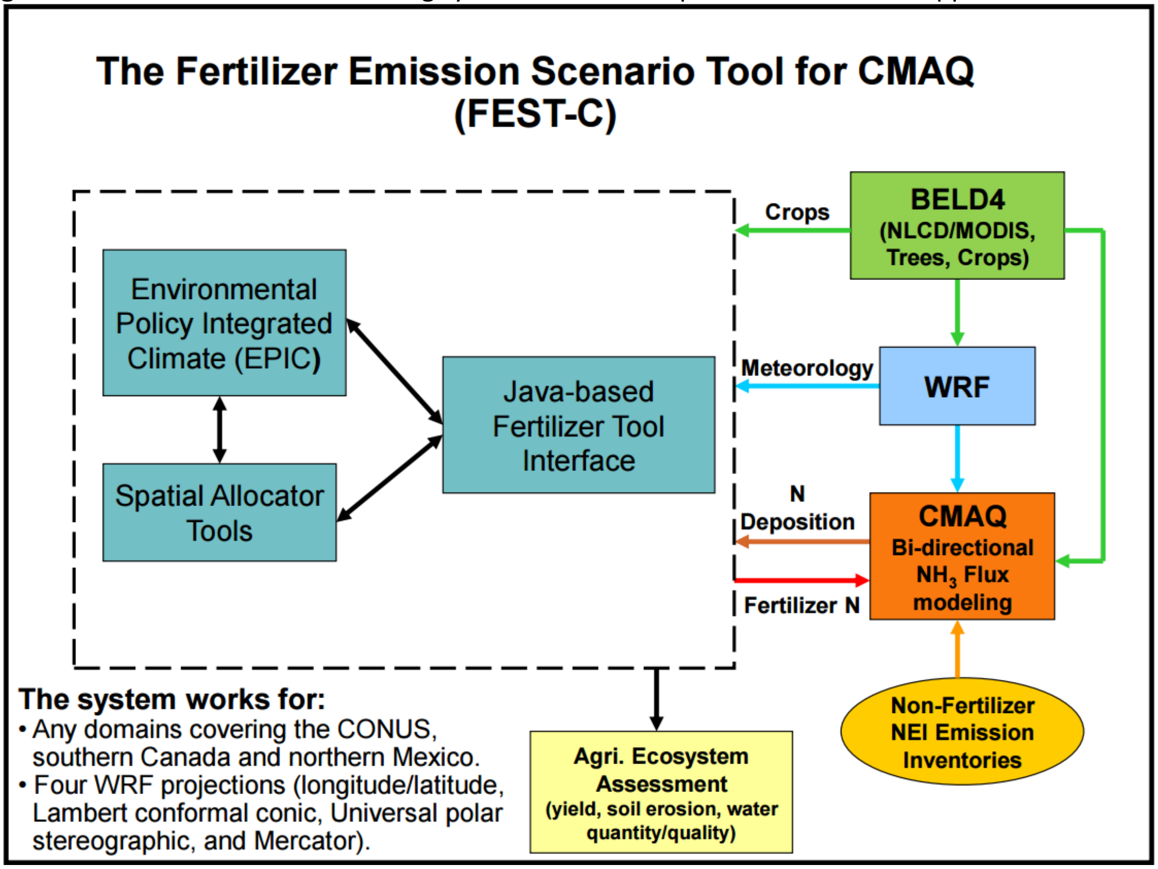
- Run FEST-C and CMAQ model with bidirectional (“bidi”) NH_3 exchange to produce year 2014 nitrate (NO_3) Ammonium (NH_4^+, including Urea), and organic (manure) nitrogen (N) fertilizer usage estimates, and gaseous ammonia NH_3 emission estimates respectively.
- Calculate county-level emission factors for 2014 as the ratio of bidirectional CMAQ NH_3 fertilizer emissions to FEST-C total N fertilizer application.
- Assign the 2014 NH_3 emissions to one SCC: “…Miscellaneous Fertilizers” (2801700099).

FEST-C reads land use data from the Biogenic Emissions Landuse Dataset (BELD) version 4, meteorological variables from the Weather Research and Forecasting (WRF v3.7.1) model [ref 3], and nitrogen deposition data from a previous or historical average CMAQ simulation. The Environmental Policy Integrated Climate (EPIC) modeling system [ref 4] provides information regarding fertilizer timing, composition, application method and amount.

The FEST-C and CMAQ simulations were used to directly estimate emission rates based on 2014 inputs. This is a refinement from the earlier 2014v1 estimates that relied on emission factors calculated from a 2011 model simulation applied to 2014 FEST-C county level fertilizer application estimates. Additionally, for 2014v2, these revised FEST-C estimates of fertilizer application were reduced for pasture and hay due to estimates of fertilizer use and hay yield being higher than USDA estimates. This resulted in a reduction of NH_3 emissions, primarily in the Southeastern U.S.

FEST-C model outputs are discussed in detail in the “NH3_Fert_Fact_Sheet_v2.docx” included in the zip file “*2014_Fertilizer_Application_v1.0_22apr2016.zip*” on the 2014v1 NEI Supplemental data FTP site. Figure 4-1 provides a comprehensive flowchart if the complete EPIC/FEST-C/WRF “bidi” modeling system.

Figure 4-1: Bidirectional flux modeling system used to compute 2014 Fertilizer Application emissions



4.4.3.1 *Activity Data*

The following activity parameters were input into the EPIC model:

- Grid cell meteorological variables from WRF (see Table 4-21)
- Initial soil profiles/soil selection
- Presence of 21 major crops: irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g. lettuce, tomatoes, etc.)
- Fertilizer sales to establish the type/composition of nutrients applied
- Management scenarios for the 10 USDA production regions (Figure 4-2) [ref 5]

Figure 4-2: USDA farm production regions used in FEST-C simulations

We used the WRF meteorological model to provide grid cell meteorological parameters for 2014 using a national 12-km rectangular grid covering the continental U.S. The meteorological parameters in Table 4-21 were used as EPIC model inputs.

Table 4-21: Environmental variables needed for an EPIC simulation

EPIC input variable	Variable Source
Daily Total Radiation (MJ m^2)	WRF
Daily Maximum 2-m Temperature (C)	WRF
Daily minimum 2-m temperature (C)	WRF
Daily Total Precipitation (mm)	WRF
Daily Average Relative Humidity (unitless)	WRF
Daily Average 10-m Wind Speed (m s^{-1})	WRF
Daily Total Wet Deposition Oxidized N (g/ha)	CMAQ
Daily Total Wet Deposition Reduced N (g/ha)	CMAQ
Daily Total Dry Deposition Oxidized N (g/ha)	CMAQ
Daily Total Dry Deposition Reduced N (g/ha)	CMAQ
Daily Total Wet Deposition Organic N (g/ha)	CMAQ

Initial soil nutrient and pH conditions in EPIC are based on the 1992 USDA Soil Conservation Service (CSC) Soils-5 survey. The EPIC model then is run for 25 years using current fertilization and agricultural cropping techniques to estimate soil nutrient content and pH for the 2014 EPIC/WRF/CMAQ simulation.

The presence of crops in each model grid cell was determined using USDA Census of Agriculture data (2012) and USGS National Land Cover data (2011). These two data sources were used to compute the fraction of agricultural land in a model grid cell and the mix of crops grown on that land.

Fertilizer sales data and the 6-month period in which they were sold were extracted from the 2006 Association of American Plant Food Control Officials (AAPFCO). AAPFCO data are used to identify the composition (e.g. urea, nitrate, organic) of the fertilizer used, and the amount applied is estimated using the modeled crop demand. These data are useful in making a reasonable assignment of what kind of fertilizer is being applied to which crops.

Management activity data refers to data used to estimate representative crop management schemes. We used the USDA Agricultural Resource Management Survey (ARMS) to provide management activity data. These data cover 10 USDA production regions and provide management schemes for irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g. lettuce, tomatoes, etc.).

4.4.3.2 *Emission Factors: revised for 2014v2*

The emission factors were derived from the 2014 FEST-C outputs (rather than 2011 FEST-C outputs used in 2014v1). Total fertilizer emission factors for each month and county were computed by taking the ratio of total fertilizer NH_3 emissions (short tons) to total nitrogen fertilizer application (short tons).

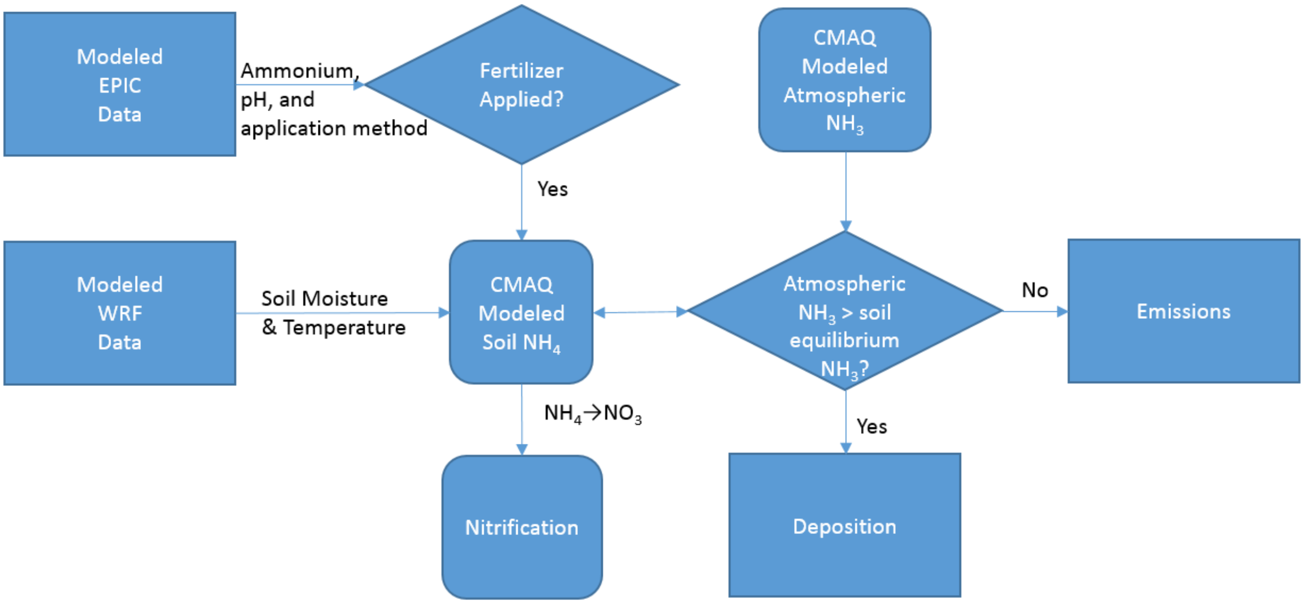
12 km by 12 km gridded NH_3 emissions were mapped into a county shape file polygon if the grid level centroid falls within the bounds of the county-level polygon. With additional time and resources, spatial allocator technique could be refined to allow for more accurate county-level estimates.

County-level fertilizer emissions (NH_3) for 2014 are estimated directly from a 2014 CMAQ model simulation.

4.4.3.3 *Example Calculation*

With this modeling system, it would be difficult to perform a sample calculation; this is not something that could be demonstrated in a spreadsheet. These emissions are computed via the full chemical transport model, as illustrated in Figure 4-3.

Figure 4-3: Simplified FEST-C system flow of operations in estimating NH_3 emissions



4.4.3.4 *Comparison to 2011 Methodology*

The 2014 NEI fertilizer estimates are based on a new "bidi" approach that couples meteorological inputs, CMAQ and the EPIC modeling system. The 2011v2 NEI fertilizer estimates are based on the Carnegie Mellon (CMU) Ammonia Model v.3.6. In short, the methodologies are completely different. Documentation of the methodology for the 2011 EPA dataset used in 2014v1 as well as the county-level data and maps used for 2014v1 are in the zip file "*2014_Fertilizer_Application_v1.0_22apr2016.zip*" on the 2014v1 NEI Supplemental data FTP site.

Emission maps for the 2011v2 NEI and the 2014v2 NEI estimates are provided below in Figure 4-4 and Figure 4-5, respectively. In addition, the "*Emissions_and_fertilizer_2011_2014_v2DRAFTrltedit.xlsx*" Excel workbook provided on the 2014v2 Supplemental Data FTP site, includes the comparison of these 2014 county-level emissions (column N) to 2011 (not 2011 NEI) estimates (column H) using the "bid" approach.

Figure 4-4: 2011v2 NEI Fertilizer Application emissions

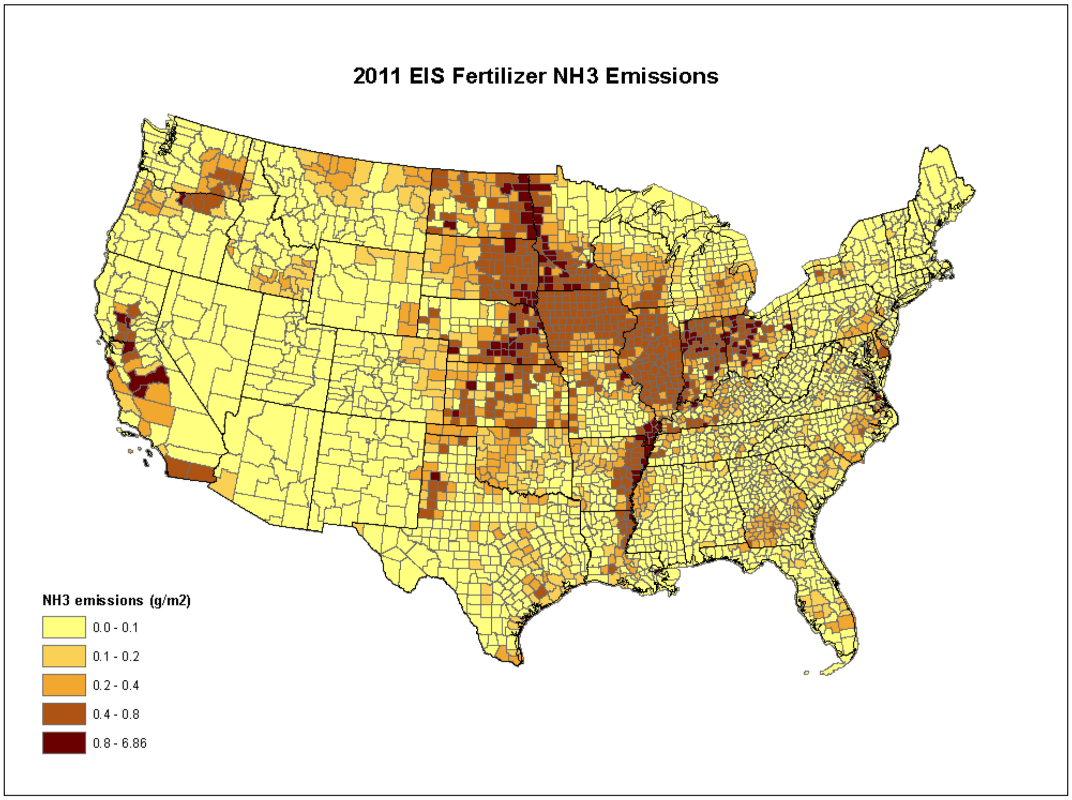
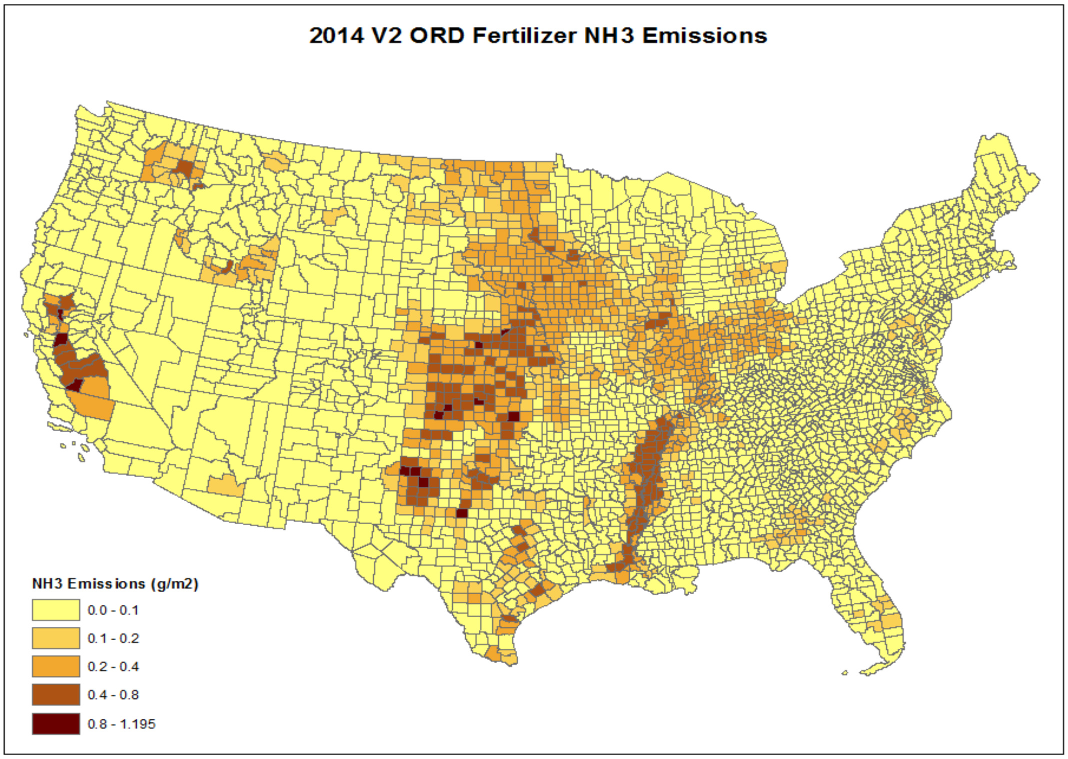


Figure 4-5: 2014v2 NEI "bidi" Fertilizer Application emissions



4.4.4 References for agriculture fertilizer application

1. Community Multiscale Air Quality (CMAQ v5.1) model, available on the CMAS web site.
2. Fertilizer Emission Scenario Tool for CMAQ (FEST-C) system, available on the CMAS FEST-C site.
3. The Weather Research Forecast (WRF) model.
4. Environmental Policy Integrated Climate (EPIC) model, available for download on the EPIC & APEX Models site.
5. Cooter, E.J., Bash, J.O., Benson V., Ran, L.-M.; Linking agricultural management and air-quality models for regional to national-scale nitrogen deposition assessments, Biogeosciences, 9, 4023-4035, 2012.

4.5 Agriculture – Livestock Waste

4.5.1 Sector description

The emissions from this category are primarily from domesticated animals intentionally reared for the production of food, fiber, or other goods or for the use of their labor. The livestock included in the EPA–estimated emissions include beef cattle, dairy cattle, ducks, geese, goats, horses, poultry, sheep, and swine. A few S/L/T agencies reported data from a few other categories in this sector such as domestic and wild animal waste, though these emissions are small compared to the livestock listed above. The domestic and wild animal waste emissions are not included for every state and not estimated by the EPA.

4.5.2 Sources of data

Table 4-22 shows the nonpoint SCCs covered by the EPA estimates and by the S/L/T agencies that submitted data. The SCC level 2, 3 and 4 descriptions are also provided. The SCC level 1 description is “Miscellaneous Area Sources” for all SCCs.

Table 4-22: Nonpoint SCCs with 2014 NEI emissions in the Livestock Waste sector

SCC	Description	EPA	State	Tribe
2805001100	Agriculture Production - Livestock; Beef cattle - finishing operations on feedlots (drylots); Confinement		X	X
2805001200	Agriculture Production - Livestock; Beef cattle - finishing operations on feedlots (drylots); Manure handling and storage		X	X
2805001300	Agriculture Production - Livestock; Beef cattle - finishing operations on feedlots (drylots); Land application of manure		X	X
2805002000	Agriculture Production - Livestock; Beef cattle production composite; Not Elsewhere Classified	X	X	X
2805003100	Agriculture Production - Livestock; Beef cattle - finishing operations on pasture/range; Confinement		X	X
2805007100	Agriculture Production - Livestock; Poultry production - layers with dry manure management systems; Confinement	X	X	X
2805007300	Agriculture Production - Livestock; Poultry production - layers with dry manure management systems; Land application of manure		X	X
2805008100	Agriculture Production - Livestock; Poultry production - layers with wet manure management systems; Confinement		X	X

SCC	Description	EPA	State	Tribe
2805008200	Agriculture Production - Livestock; Poultry production - layers with wet manure management systems; Manure handling and storage		X	X
2805008300	Agriculture Production - Livestock; Poultry production - layers with wet manure management systems; Land application of manure		X	X
2805009100	Agriculture Production - Livestock; Poultry production - broilers; Confinement	X	X	X
2805009200	Agriculture Production - Livestock; Poultry production - broilers; Manure handling and storage		X	X
2805009300	Agriculture Production - Livestock; Poultry production - broilers; Land application of manure		X	X
2805010100	Agriculture Production - Livestock; Poultry production - turkeys; Confinement		X	X
2805010200	Agriculture Production - Livestock; Poultry production - turkeys; Manure handling and storage		X	X
2805010300	Agriculture Production - Livestock; Poultry production - turkeys; Land application of manure		X	X
2805018000	Agriculture Production - Livestock; Dairy cattle composite; Not Elsewhere Classified	X	X	X
2805019100	Agriculture Production - Livestock; Dairy cattle - flush dairy; Confinement		X	X
2805019200	Agriculture Production - Livestock; Dairy cattle - flush dairy; Manure handling and storage		X	X
2805019300	Agriculture Production - Livestock; Dairy cattle - flush dairy; Land application of manure		X	X
2805020002	Agriculture Production - Livestock; Cattle and Calves Waste Emissions; Beef Cows		X	X
2805021100	Agriculture Production - Livestock; Dairy cattle - scrape dairy; Confinement		X	X
2805021200	Agriculture Production - Livestock; Dairy cattle - scrape dairy; Manure handling and storage		X	X
2805021300	Agriculture Production - Livestock; Dairy cattle - scrape dairy; Land application of manure		X	X
2805022100	Agriculture Production - Livestock; Dairy cattle - deep pit dairy; Confinement		X	X
2805022200	Agriculture Production - Livestock; Dairy cattle - deep pit dairy; Manure handling and storage		X	X
2805022300	Agriculture Production - Livestock; Dairy cattle - deep pit dairy; Land application of manure		X	X
2805023100	Agriculture Production - Livestock; Dairy cattle - drylot/pasture dairy; Confinement		X	X
2805023200	Agriculture Production - Livestock; Dairy cattle - drylot/pasture dairy; Manure handling and storage		X	X

SCC	Description	EPA	State	Tribe
2805023300	Agriculture Production - Livestock; Dairy cattle - drylot/pasture dairy; Land application of manure		X	X
2805025000	Agriculture Production - Livestock; Swine production composite; Not Elsewhere Classified (see also 28-05-039, -047, -053)	X	X	X
2805030000	Agriculture Production - Livestock; Poultry Waste Emissions; Not Elsewhere Classified (see also 28-05-007, -008, -009)		X	X
2805030007	Agriculture Production - Livestock; Poultry Waste Emissions; Ducks	X	X	X
2805030008	Agriculture Production - Livestock; Poultry Waste Emissions; Geese	X	X	X
2805035000	Agriculture Production - Livestock; Horses and Ponies Waste Emissions; Not Elsewhere Classified	X	X	X
2805039100	Agriculture Production - Livestock; Swine production - operations with lagoons (unspecified animal age); Confinement		X	X
2805039200	Agriculture Production - Livestock; Swine production - operations with lagoons (unspecified animal age); Manure handling and storage		X	X
2805039300	Agriculture Production - Livestock; Swine production - operations with lagoons (unspecified animal age); Land application of manure		X	X
2805040000	Agriculture Production - Livestock; Sheep and Lambs Waste Emissions; Total	X	X	X
2805045000	Agriculture Production - Livestock; Goats Waste Emissions; Not Elsewhere Classified	X	X	X
2805047100	Agriculture Production - Livestock; Swine production - deep-pit house operations (unspecified animal age); Confinement		X	X
2805047300	Agriculture Production - Livestock; Swine production - deep-pit house operations (unspecified animal age); Land application of manure		X	X
2805053100	Agriculture Production - Livestock; Swine production - outdoor operations (unspecified animal age); Confinement		X	X
2806010000	Domestic Animals Waste Emissions; Cats; Total		X	
2806015000	Domestic Animals Waste Emissions; Dogs; Total		X	
2807020001	Wild Animals Waste Emissions; Bears; Black Bears		X	
2807020002	Wild Animals Waste Emissions; Bears; Grizzly Bears		X	
2807025000	Wild Animals Waste Emissions; Elk; Total		X	
2807030000	Wild Animals Waste Emissions; Deer; Total		X	
2807040000	Wild Animals Waste Emissions; Birds; Total		X	

Table 4-23 presents the three “Industrial Processes” point SCCs reported by 2 states: California and Wisconsin. Point source emissions from this sector are negligible, particularly for NH_3, compared to the nonpoint emissions (3 orders of magnitude lower). The SCC level 1 and 2 descriptions is “Industrial Processes; Food and Agriculture” for all SCCs.

Table 4-23: Point SCCs with 2014 NEI emissions in the Livestock Waste sector – reported only by States

SCC	SCC Level Three	SCC Level Four	CA	WI
30202001	Beef Cattle Feedlots	Feedlots: General	X	X

SCC	SCC Level Three	SCC Level Four	CA	WI
30202020	Dairy Cattle	Enteric, Confinement, Manure Handling, Storage, Land Application	X	
30202101	Eggs and Poultry Production	Manure Handling: Dry	X	

The agencies listed in Table 4-24 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-24: Percentage of total Livestock NH_3 emissions submitted by reporting agency

Region	Agency	S/L/T	Ammonia
1	Maine Department of Environmental Protection	State	32
2	New Jersey Department of Environment Protection	State	80
3	Delaware Department of Natural Resources and Environmental Control	State	98
4	Georgia Department of Natural Resources	State	3
5	Illinois Environmental Protection Agency	State	98
6	United Keetoowah Band of Cherokee Indians in Oklahoma	Tribe	100
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	100
8	Utah Division of Air Quality	State	21
9	California Air Resources Board	State	46
10	Coeur d'Alene Tribe	Tribe	100
10	Idaho Department of Environmental Quality	State	100
10	Kootenai Tribe of Idaho	Tribe	100
10	Nez Perce Tribe	Tribe	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100

4.5.3 EPA-developed livestock waste emissions data: new for 2014v2

Animal waste from livestock results in emissions of both NH3 (ammonia) and, new for 2014v2, Volatile Organic Compounds (VOCs). VOCs emitted by livestock can be defined as any compound of carbon (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate) that may participate in atmospheric photochemical reactions and is emitted by livestock. Livestock are domesticated farm animals raised in an agricultural setting for home use or profit. Following the work of Carnegie Mellon University (CMU), the following livestock were evaluated: dairy cattle, beef cattle, swine, and poultry (layers and broilers).

The general approach to calculating NH3 emissions due to livestock is to multiply the emission factor (in kg per year per animal) by the number of animals in the county. VOC emissions were estimated by multiplying a national VOC/NH3 emissions ratio by the county NH3 emissions.

In the 2014 NEI, the EPA methodology for ammonia emissions includes all processes from the housing/grazing, storage and application of manure from beef cattle, dairy cattle, swine, broiler chicken, and layer chicken production, and these are assigned to the SCCs listed in Table 4-25. The SCC level 1 and 2 descriptions is "Miscellaneous Area Sources; Agriculture Production - Livestock" for all SCCs.

Table 4-25: EPA-estimated livestock emission SCCs

SCC	SCC Level 3 Description	SCC Level 4 Description
2805002000	Beef cattle production composite	Not Elsewhere Classified
2805007100	Poultry production - layers with dry manure management systems; Confinement	Confinement
2805009100	Poultry production - broilers; Confinement	Confinement
2805018000	Dairy cattle composite	Not Elsewhere Classified
2805025000	Swine production composite	Not Elsewhere Classified

Cows, swine and chickens account for 95% of national NH_3 emissions from livestock waste in 2014. However, there are also emissions from other animals such as horses, turkeys, goats, etc. Due to resource constraints at EPA, 2014 emissions were not updated for several animal types and are assumed to be the same as 2011 emissions, except in cases where S/L/T agencies provided updated 2014 emissions for these sources. These EPA-estimated emissions, carried forward from the 2011 NEI, are listed in Table 4-26. The SCC level 1 and 2 descriptions is "Miscellaneous Area Sources; Agriculture Production - Livestock" for all SCCs.

Table 4-26: EPA-estimated sources carried forward from 2011

SCC	SCC Level 3 Description	SCC Level 4 Description
2805030007	Poultry Waste Emissions	Ducks
2805030008	Poultry Waste Emissions	Geese
2805035000	Horses and Ponies Waste Emissions	Not Elsewhere Classified
2805040000	Sheep and Lambs Waste Emissions	Total
2805045000	Goats Waste Emissions	Not Elsewhere Classified

4.5.3.1 *Activity Data*

The United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) Quick Stats program [ref 18] was utilized to obtain the activity data. The 2014 USDA Survey was used to obtain the livestock count for as many counties as possible across the United States. Because the survey did not cover the entire country, the USDA 2012 Census was used to fill in much of the remaining entities. However, the 2012 Census and the 2014 Survey were not spatially complete when combined, so it was necessary to calculate the missing county data using the methods described below. Table 4-27 outlines the use of the 2012 Census and 2014 Survey in the creation of the livestock populations.

Table 4-27: Summary of Use of 2014 Survey or 2012 Census Animal Populations

Animal Type	Source
Broilers	There is no 2014 data in the Survey on Broiler Inventory at either the county or state level. Therefore, the inventory reflects the 2012 state level totals. 2014v2 NEI county level populations were adjusted to ensure that the county totals match the 2012 state level totals.
Layers	For Layers, the 2014v2 NEI animal populations are based on 2012 state level inventories, with a few exceptions. These inventories have been updated to reflect the 2014 state level inventories where 2014 data was available. There were 30 states with 2014 state level layer population data, and a growth factor was applied to 2012 county level populations to reflect the change in population between 2012 and 2014 state level totals.

Animal Type	Source
Hogs	For hogs, there were four states in the 2014v1 NEI dataset that had 2014 county level data (MT, NC, ND, OK). No update is needed for those four. The other 46 states were updated to reflect the 2014 state level total. The county populations were multiplied by the growth factor between the NASS 2012 and 2014 state level data. This allows all 50 states to have the sum of their county inventories match the 2014 NASS State level data.
Dairy Cattle	No update was provided to the 2014v1 NEI dataset, except for a few states with error corrections. The sum of all county level data for each state matches the NASS state inventory totals.
Beef Cattle	No update was provided to the 2014v1 NEI dataset. The sum of all county level data for each state matches the NASS state inventory totals.

For Swine and Poultry: For missing counties, the total value for the counties present is added up and then subtracted from the statewide reported value. This will result in the missing number of animals from the state. From there, the number of counties reporting (D – Did not report) are counted and the total missing animals is divided by the number of counties that did not report. This resulting number is then allocated to each county that reported a (D) value. The counties skipped in the survey are given a value of 0.

Example:

County 1: 20
County 2: 45
County 3: (D)
County 4: 5
County 5: (D)
State total: 100

5. Calculate sum of all counties: 20 + 45 + 5 = 70
6. Calculate number of cattle missing from counties: 100 – 70 = 30
7. Since 2 states did not report values: 30/2 =15
8. Allocate 15 animals to County 3 and 15 animals to County 5

Therefore, the county animal totals are as follows:

County 1: 20
County 2: 45
County 3: 15
County 4: 5
County 5: 15

For Cattle: Following the work of CMU, the total beef cattle is equal to the total cattle (including calves) minus the dairy cattle. To get the correct number of total cattle, a method similar to what is described above is used. For the counties missing data, the total value for the counties present is added up and then subtracted from the statewide reported value. This number is then divided by the total number of states that did not report the total number of cattle. The dairy cattle missing in each county are calculated using the formula:

Dairy Cattle = # Dairy Cattle missing in county*(Total Cattle (incl. calves) in county/sum of Total Cattle in all counties missing data)

Then, finally, the beef cattle can be calculated using the formula:

Beef Cattle = Total # Cattle - # Dairy Cattle

Example:

County	Total Cattle (including calves)	Beef Cattle	Dairy Cattle
1	30		20
2	100		30
3	20		(D)
4	(D)		(D)
5	(D)		10

Total State Cattle: 250
Total Dairy Cattle: 100

4. Get total cattle: 30+100+20 = 150
   Total missing cattle: 100, therefore 50 cattle go to each county that did not report

County	Total Cattle (including calves)	Beef Cattle	Dairy Cattle
1	30		20
2	100		30
3	20		(D)
4	**50**		(D)
5	**50**		10

5. Get total dairy cattle:
   Missing number of dairy cattle: 100 – 20 – 30 – 10 = 40
   Total number of cattle in counties missing dairy: 20 + 50 = 70
   # dairy/county = 40* (total number of cattle in missing county/70)
   Therefore, the number of dairy cattle in:
   County 3 = 40*(20/70) = ~11
   County 4 = 40*(50/70) = ~29

County	Total Cattle (including calves)	Beef Cattle	Dairy Cattle
1	30		20
2	100		30
3	20		**11**
4	**50**		**29**
5	**50**		10

6. Calculate total beef by subtracting dairy cattle from total cattle.*

County	Total Cattle (including calves)	Beef Cattle	Dairy Cattle
1	30	10	20
2	100	70	30
3	20	9	**11**
4	**50**	21	**29**
5	**50**	40	10
Sum	**250**	**150**	**100**

*It is important to note that the total beef cattle obtained from the US Census is the actual total for beef cattle in each county. However, the procedures listed above were followed for the census data when data wasn't given.

4.5.3.2 *Emission Factors*

CMU developed a new model to estimate daily ammonia emission factors for cows, swine and chickens. The model estimates emissions from a typical farm, using a particular set of practices, for a particular set of meteorological conditions [refs 1-1]. The model estimates the mass balance of nitrogen through the farm system, accounting for nitrogen lost to the atmosphere and infiltrated into the soil.

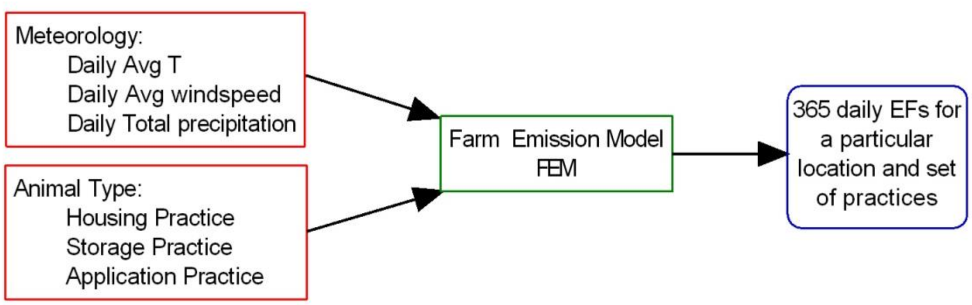
CMU developed a model to estimate NH_3 emissions from livestock [ref 1]. The model estimates emissions from a typical farm, using a particular set of practices, for a particular set of meteorological conditions [ref 2, ref 3]. The model estimates the mass balance of nitrogen through the farm system, accounting for nitrogen lost to the atmosphere and infiltrated into the soil.

This model produces daily-resolved, climate level emissions factors for a particular distribution of management practices for each county and animal type, as expressed as emissions/animal. These county level emissions factors are then combined together to create a state level emissions factor for each animal type. These state level emissions factors were back calculated from the CMU model using statewide emissions divided by statewide animal totals, and those are the emissions factors used in this analysis. Thus, the CMU model provides a state specific NH3 emissions/head emission factor for each animal type.

VOC emission factors come from the ratio of NH_3 to VOC emissions in counties which provided an estimate of both pollutants in the 2014 v1 NEI. There were 106 counties which provided emissions for both pollutants, and the average ratio was 0.08 tons of VOC for every ton of NH3. This ratio is multiplied by all county level NH3 emissions in NEI 2014v2 to estimate VOC emissions for each county. This ratio does not vary by state or animal type.

The model inputs and outputs are shown in Figure 4-6.

Figure 4-6: Process to produce location and practice specific daily emission factors



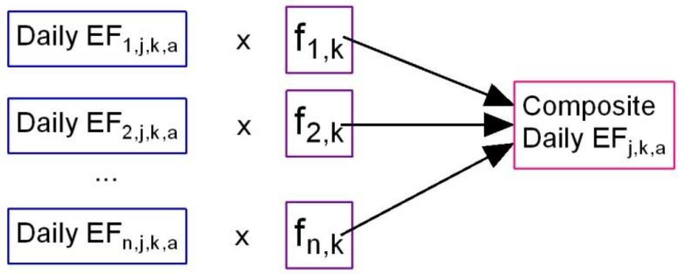
The calculation procedure to translate the output for a particular farm/farm configuration is shown in Figure 4-7. The US distribution of management practices is based on reports from the NAHMS (National Animal Health Monitoring Study) [ref 4 – ref 16] and are provided by management practice in Table 4-28.

Table 4-28: Reference links for each management practice

Management Practice	Reference(s)
Swine	5, 15, 16
Dairy	6, 7
Beef	10
Poultry	4, 9, 14
Layers	12, 13

Management Practice	Reference(s)
Feedlots	8, 11

Figure 4-7: Composite emission factors for a specific day, location, and animal type



County-level emissions for an animal type for a particular day were calculated as shown in Equation 1.

$$Emissions_{j,k,a}\left(\frac{kg}{d \cdot county}\right) = Daily\ EF_{j,k,a} \times Population_{k,a} \tag{1}$$

The total emissions in any given day were then be calculated by adding up all the emissions in each county for all animal types. This is shown in Equation 2.

$$Emissions_{j,k}\left(\frac{kg}{d \cdot county}\right) = \sum_{a=1}^{all\ animal\ types} Emissions_{j,k,a}\left(\frac{kg}{d \cdot county}\right) \tag{2}$$

Total annual emissions for each location were calculated by summing the daily emissions over the entire year; this is described in Equation 3.

$$Emissions_{k}\left(\frac{kg}{y}\right) = \sum_{j=1}^{365} Emissions_{j,k}\left(\frac{kg}{d \cdot county}\right) \tag{3}$$

The calculation that was completed for total annual emissions (for all animal types and all locations) is shown in Equation 4.

$$Emissions_{total}\left(\frac{kg}{y}\right) = \sum_{k=1}^{US\ Counties} Emissions_{k}\left(\frac{kg}{d \cdot county}\right) \tag{4}$$

4.5.3.3 *Example Calculation*

A general method to calculate the emissions per county for a given pollutant can be calculated by multiplying the emission factor for the given livestock type by the animal activity in each county.

Back Calculating the Emissions Factors from the CMU Model

The emissions estimates in the 2014v1 NEI came from the CMU model. These emissions were then divided by the model's animal population figures to estimate the statewide NH_3 emission factor. In Cochise County, AZ, there were 925 head of swine [ref 17, ref 18]. Those accounted for 9370 kg of NH_3.

State NH3 Emissions Factor = Emissions / Number of Animals
= 9370 / 925
= 10.13 kg NH_3/head

Note that this EF is the same for all counties in Arizona. Pima County had 5744 kg of $NH_3$and 567 head of swine, or 10.13 kg NH_3/head.

NH_3 Emission due to Livestock

Emissions are calculated by multiplying the state specific NH_3 emission factor (in NH_3/head) by the number of animals in each county. For example, in Calhoun County, AL, there were 7,400 head of beef cattle in 2014. The Alabama emission factor for beef cattle from the CMU model was 3.68 kg of NH_3/head/year.

Calculate the emissions:

Beef Cattle NH3 Emissions	= Emission Factor * Number of Animals
	= 3.68 * 7,400
	= 27,224 kg NH_3

VOC Emission due to Livestock

VOC emissions are calculated using the ratio of VOC to NH_3 emissions from livestock. That ratio is 0.08 kg of VOC for every kg of NH_3. Therefore, the VOC emissions from beef cattle in Calhoun County, AL would be calculated as follows:

Beef Cattle VOC Emissions	= VOC/NH3 ratio * NH3 Emissions
	= 0.08 * 27,224 kg NH3
	= 2,186 kg VOC

4.5.3.4 *Improvements in the 2014v2 NEI*

The animal populations used in the 2014v1 NEI had several consistent problems which have been corrected. In many cases, the total animal population of all counties is significantly different from the NASS state population total for either 2012 or 2014. For example, the 2014v1 NEI had a total swine population of 109,000, which does not match the state total in the NASS for either 2012 or 2014. This has been corrected so that the total swine inventory in Arizona counties equals the 2014 NASS state total of 139,000. This type of error occurs in other animal datasets as well. For broilers, there were no 2014 state level NASS animal populations, so the data should reflect the 2012 state level census data. The 2014v1 NEI showed a broiler population of 13,402 in Rhode Island, while the 2012 dataset shows a population of 18,396. Matching the 2014v2 NEI dataset with the most recently available state level totals (either 2012 or 2014) ensures an improved animal population dataset than that seen in the 2014v1 NEI.

Estimation of Hazardous Air Pollutants (HAPs) for Livestock

HAPs for this sector were estimated by multiplying county-specific VOC emissions by speciation factors that are animal-specific as shown in Table 4-29. All the HAP VOC fractions were obtained from EPA's SPECIATE database [ref 19]. As per the availability in SPECIATE, there are total of 6 VOC HAPs estimated for beef cattle, 5 VOC HAPs for dairy cattle, 4 VOC HAPs for swine, and 14 (same) VOC HAPs for layers and broilers (poultry).

Table 4-29: VOC speciation fractions used to estimate HAP Emissions for the Livestock Sector

SCC	Animal Type	HAP	Fraction of VOC	SPECIATE Profile Number
280500200	Beef Cattle	1,4-Dichlorobenzene	0.0013	95240
280500200	Beef Cattle	Methyl isobutyl Ketone	0.0008	
280500200	Beef Cattle	Toluene	0.011	
280500200	Beef Cattle	Chlorobenzene	0.0001	
280500200	Beef Cattle	Phenol	0.0006	
280500200	Beef Cattle	Benzene	0.0001	
2805007100	Poultry---Layers	Methyl isobutyl ketone	0.0169	95223
2805007100	Poultry---Layers	Toluene	0.0018	
2805007100	Poultry---Layers	Phenol	0.0024	
2805007100	Poultry---Layers	N-hexane	0.0111	
2805007100	Poultry---Layers	Chloroform	0.0025	
2805007100	Poultry---Layers	Cresol/Cresylic Acid (mixed isomers)	0.0048	
2805007100	Poultry---Layers	Acetamide	0.0075	
2805007100	Poultry---Layers	Methanol	0.0608	
2805007100	Poultry---Layers	Benzene	0.0052	
2805007100	Poultry---Layers	Ethyl Chloride	0.0031	
2805007100	Poultry---Layers	Acetonitrile	0.0088	
2805007100	Poultry---Layers	Dichloromethane	0.0002	
2805007100	Poultry---Layers	Carbon Disulfide	0.0034	
2805007100	Poultry---Layers	2-Methyl Naphthalene	0.0006	
2805009100	Poultry-Broilers	Methyl isobutyl ketone	0.0169	95223
2805009100	Poultry-Broilers	Toluene	0.0018	
2805009100	Poultry-Broilers	Phenol	0.0024	
2805009100	Poultry-Broilers	N-hexane	0.0111	
2805009100	Poultry-Broilers	Chloroform	0.0025	
2805009100	Poultry-Broilers	Cresol/Cresylic Acid (mixed isomers)	0.0048	
2805009100	Poultry-Broilers	Acetamide	0.0075	
2805009100	Poultry-Broilers	Methanol	0.0608	
2805009100	Poultry-Broilers	Benzene	0.0052	
2805009100	Poultry-Broilers	Ethyl Chloride	0.0031	
2805009100	Poultry-Broilers	Acetonitrile	0.0088	
2805009100	Poultry-Broilers	Dichloromethane	0.0002	
2805009100	Poultry-Broilers	Carbon Disulfide	0.0034	
2805009100	Poultry-Broilers	2-Methyl Naphthalene	0.0006	
2805018000	Dairy Cattle	Toluene	0.0018	8897
2805018000	Dairy Cattle	Cresol/Cresylic Acid (mixed isomers)	0.0276	
2805018000	Dairy Cattle	Xylenes (mixed isomers)	0.0046	
2805018000	Dairy Cattle	Methanol	0.3542	
2805018000	Dairy Cattle	Acetaldehyde	0.0141	
2805025000	Swine	Toluene	0.0047	95241
2805025000	Swine	Phenol (Carbolic Acid)	0.0179	
2805025000	Swine	Benzene	0.0035	
2805025000	Swine	Acetaldehyde	0.0155	

Other pollutants reported for this sector

It should be noted that EPA only estimated NH3, VOC, and VOC-HAPs (as listed above) for this sector. Other pollutants reported (such as PM) come entirely from SLT-reported estimates. HAPs were estimated according to the VOC emissions generated by EPA using the fractions shown in Table 4-29, when there was no SLT-reported VOC value.

4.5.3.5 *Comparison to 2011 methodology*

The NEI 2011v2 EPA methodology was mostly based on the CMU Ammonia Model v. 3.6 which attributed monthly emissions as a function of temperature to calculate ammonia emissions with county-level animal populations and emission factors. The EPA did modify some of the emission factors from the original model for the 2011 NEI. Additional documentation for the 2011 inventory can be found in the 2011 National Emissions Inventory, version 2 Technical Support Document.

In contrast, the 2014 emissions inventory for dairy and beef cattle, hogs and poultry are based on the daily emission factors for a regionally specific distribution of manure management practices. 2014 emissions for all other animals are unchanged from 2011 methodology.

4.5.4 References for agriculture livestock waste

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11. USDA-APHIS, 2013. Feedlot 2011 -- Part II: Management Practices on US Feedlots with a capacity of Fewer than 1000 Head.
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13. USDA-APHIS, 2000. Part II: Reference of 1999 Table Egg Layer Management in the US.
14. USDA-APHIS, 2005. Poultry ’04 -- Part II: Reference of Health and Management of Gamefowl Breeder Flocks in the United States, 2004.

15. USDA-APHIS, 2008. Swine 2006 -- Part IV: Changes in the US Pork Industry, 1990-2006.
16. USDA-APHIS, 2008. Swine 2006 -- Part II: Reference of Swine Health and Health Management Practices in the United States, 2006.
17. USDA-NASS, 2012. 2012 Census of Agriculture.
18. USDA-NASS, 2014. National Agricultural Statistics Service: Quick Stats.
19. U.S. Environmental Protection Agency. 2016. SPECIATE Database v4.5.

4.6 Nonpoint Gasoline Distribution

This section includes discussion of all nonpoint sources in three EIS sectors: Bulk Gasoline Terminals, Gas Stations, and Industrial Processes – Storage and Transfer. Many of the sources in these sectors include sources reported to the point inventory as well; therefore, the EPA nonpoint survey is useful to avoid double-counting S/L/T-reported point emissions with EPA-estimated nonpoint emissions.

4.6.1 Description of sources

This section is broken into two categories: those sources related to Stage 1 gasoline distribution, and those related to aviation gasoline.

4.6.1.1 Stage 1 Gasoline Distribution

Stage 1 gasoline distribution is covered by the 2014 NEI in both the point and nonpoint data categories. In general terms, Stage 1 gasoline distribution is the emissions associated with gasoline handling excluding emissions from refueling activities. Stage 1 gasoline distribution includes the following gasoline-specific emission sources: 1) bulk terminals; 2) pipeline facilities; 3) bulk plants; 4) tank trucks; and 5) service stations (which can be further subdivided into Filling and Breathing & Emptying). Emissions from Stage 1 gasoline distribution occur as gasoline vapors are released into the atmosphere. These stage 1 processes are subject to the EPA's maximum available control technology (MACT) standards for gasoline distribution.

Emissions from gasoline distribution at bulk terminals and bulk plants take place when gasoline is loaded into a storage tank or tank truck, from working losses (for fixed roof tanks), and from working losses and roof seals (for floating roof tanks). Working losses consist of both breathing and emptying losses. Breathing losses are the expulsion of vapor from a tank vapor space that has expanded or contracted because of daily changes in temperature and barometric pressure; these emissions occur in the absence of any liquid level change in the tank. Emptying losses occur when the air that is drawn into the tank during liquid removal saturates with hydrocarbon vapor and expands, thus exceeding the fixed capacity of the vapor space and overflowing through the pressure vacuum valve.

Emissions from tank trucks in transit occur when gasoline vapor evaporates from (1) loaded tank trucks during transportation of gasoline from bulk terminals/plants to service stations, and (2) empty tank trucks returning from service stations to bulk terminals/plants. Pipeline emissions result from the valves and pumps found at pipeline pumping stations and from the valves, pumps, and storage tanks at pipeline breakout stations. Stage 1 gasoline distribution emissions also occur when gasoline vapors are displaced from storage tanks during unloading of gasoline from tank trucks at service stations (Gasoline Service Station Unloading) and from gasoline vapors evaporating from service station storage tanks and from the lines going to the pumps (Underground Storage Tank Breathing and Emptying).

4.6.1.2 *Aviation Gasoline, Stage 1 and 2*

Aviation gasoline is another piece of the Gasoline Distribution grouping in the NEI, and fall under the sector "gas stations." It is the only aviation fuel that contains lead as a knock-out component for small reciprocating, piston-engine crafts in civil aviation. Commercial and military aviation rarely use this fuel. Aviation Gasoline is shipped to airports and is filled into bulk terminals, and then into tanker trucks. These processes fall under the definition of stage 1, displacement vapors during the transfer of gasoline from tank trucks to storage tanks, and vice versa. These processes are subject to EPA's maximum available control technology (MACT) standards for gasoline distribution. Stage 2, on the other hand, involves the transfer of fuel from the tanker trucks into general aviation aircraft.

4.6.2 Sources of data

Sources in the EIS sectors for Bulk Gasoline Terminals, Gas Stations, and Industrial Processes – Storage and Transfer do not focus solely on gasoline; however, for the purposes of developing the NEI, these SCCs are the only ones that EPA estimates in these sectors. EPA does not develop calculation tools that estimate emissions from transfer of naphtha, distillate oil, inorganic chemicals, kerosene, residual oil, or crude oil. Therefore, sector level emissions for these three EIS sectors will include sources not related to gasoline distribution, some from the point inventory.

Table 4-30 shows all non-Aviation Gasoline SCCs in the nonpoint data category for EIS sectors Bulk Gasoline Terminals, Gas Stations, and Industrial Processes – Storage and Transfer. For Stage 1 Gasoline Distribution, the nonpoint SCCs covered by the EPA estimates are also noted. Table 4-31 shows, for Aviation Gasoline, the nonpoint SCCs covered by the EPA estimates and by the S/L/T agencies that submitted data. The SCC level 2, 3 and 4 SCC descriptions are also provided. The SCC level 1 description is "Storage and Transport" for all SCCs in both tables.

Table 4-30: Nonpoint Bulk Gasoline Terminals, Gas Stations, and Storage and Transfer SCCs with 2014 NEI emissions

SCC	Description	Sector	EPA	State	Local	Tribe
2501000150	Petroleum and Petroleum Product Storage; All Storage Types: Breathing Loss; Jet Naphtha	Industrial Processes - Storage and Transfer		X		
2501050120	Petroleum and Petroleum Product Storage; Bulk Terminals: All Evaporative Losses; Gasoline	Bulk Gasoline Terminals	X	X	X	
2501055120	Petroleum and Petroleum Product Storage; Bulk Plants: All Evaporative Losses; Gasoline	Bulk Gasoline Terminals	X	X	X	
2501060050	Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Total	Gas Stations		X		
2501060051	Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Submerged Filling	Gas Stations	X	X	X	
2501060052	Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Splash Filling	Gas Stations	X	X		X

SCC	Description	Sector	EPA	State	Local	Tribe
2501060053	Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Balanced Submerged Filling	Gas Stations	X	X	X	X
2501060201	Petroleum and Petroleum Product Storage; Gasoline Service Stations; Underground Tank: Breathing and Emptying	Gas Stations	X	X	X	X
2501070053	Petroleum and Petroleum Product Storage; Diesel Service Stations; Stage 1: Balanced Submerged Filling	Gas Stations		X		X
2501070201	Petroleum and Petroleum Product Storage; Diesel Service Stations; Underground Tank: Breathing and Emptying	Gas Stations				X
2501995120	Petroleum and Petroleum Product Storage; All Storage Types: Working Loss; Gasoline	Industrial Processes - Storage and Transfer		X		
2501995180	Petroleum and Petroleum Product Storage; All Storage Types: Working Loss; Kerosene	Industrial Processes - Storage and Transfer		X		
2505000120	Petroleum and Petroleum Product Transport; All Transport Types; Gasoline	Industrial Processes - Storage and Transfer		X		
2505010000	Petroleum and Petroleum Product Transport; Rail Tank Car; Total: All Products	Industrial Processes - Storage and Transfer		X		
2505020000	Petroleum and Petroleum Product Transport; Marine Vessel; Total: All Products	Industrial Processes - Storage and Transfer		X		
2505020030	Petroleum and Petroleum Product Transport; Marine Vessel; Crude Oil	Industrial Processes - Storage and Transfer		X		
2505020060	Petroleum and Petroleum Product Transport; Marine Vessel; Residual Oil	Industrial Processes - Storage and Transfer		X		
2505020090	Petroleum and Petroleum Product Transport; Marine Vessel; Distillate Oil	Industrial Processes - Storage and Transfer		X		
2505020120	Petroleum and Petroleum Product Transport; Marine Vessel; Gasoline	Industrial Processes - Storage and Transfer		X		
2505020150	Petroleum and Petroleum Product Transport; Marine Vessel; Jet Naphtha	Industrial Processes - Storage and Transfer		X		
2505020180	Petroleum and Petroleum Product Transport; Marine Vessel; Kerosene	Industrial Processes - Storage and Transfer		X		
2505020900	Petroleum and Petroleum Product Transport; Marine Vessel; Tank Cleaning	Industrial Processes - Storage and Transfer		X		
2505030120	Petroleum and Petroleum Product Transport; Truck; Gasoline	Industrial Processes - Storage and Transfer	X	X	X	X

SCC	Description	Sector	EPA	State	Local	Tribe
2505040120	Petroleum and Petroleum Product Transport; Pipeline; Gasoline	Industrial Processes - Storage and Transfer	X	X		
2510000000	Organic Chemical Storage; All Storage Types: Breathing Loss; Total: All Products	Industrial Processes - Storage and Transfer			X	
2520010000	Inorganic Chemical Storage; Commercial/Industrial: Breathing Loss; Total: All Products	Industrial Processes - Storage and Transfer		X		
2525000000	Inorganic Chemical Transport; All Transport Types; Total: All Products	Industrial Processes - Storage and Transfer		X		

Table 4-31: Nonpoint Aviation Gasoline Distribution SCCs with 2014 NEI emissions

SCC	Description	Sector	EPA	State	Local	Tribe
2501080050	Petroleum and Petroleum Product Storage; Airports: Aviation Gasoline; Stage 1: Total	Gas Stations	X	X		
2501080100	Petroleum and Petroleum Product Storage; Airports: Aviation Gasoline; Stage 2: Total	Gas Stations	X	X		
2501080201	Petroleum and Petroleum Product Storage; Airports: Aviation Gasoline; Underground Tank Breathing and Emptying	Gas Stations		X		

The agencies listed in Table 4-32 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-32: Percentage of Gasoline Distribution VOC emissions submitted by reporting agency

Region	Agency	Sector	VOC
1	Maine Department of Environmental Protection	Gas Stations	27
1	Massachusetts Department of Environmental Protection	Bulk Gasoline Terminals	100
1	Massachusetts Department of Environmental Protection	Gas Stations	85
1	Massachusetts Department of Environmental Protection	Industrial Processes - Storage and Transfer	15
1	New Hampshire Department of Environmental Services	Gas Stations	56
1	New Hampshire Department of Environmental Services	Industrial Processes - Storage and Transfer	100
2	New Jersey Department of Environment Protection	Gas Stations	100
2	New Jersey Department of Environment Protection	Industrial Processes - Storage and Transfer	100
2	New York State Department of Environmental Conservation	Bulk Gasoline Terminals	100
2	New York State Department of Environmental Conservation	Gas Stations	100
2	New York State Department of Environmental Conservation	Industrial Processes - Storage and Transfer	100
3	Delaware Department of Natural Resources and Environmental Control	Gas Stations	100

Region	Agency	Sector	VOC
3	Delaware Department of Natural Resources and Environmental Control	Industrial Processes - Storage and Transfer	100
3	Maryland Department of the Environment	Gas Stations	100
3	Maryland Department of the Environment	Industrial Processes - Storage and Transfer	100
3	Virginia Department of Environmental Quality	Gas Stations	95
3	Virginia Department of Environmental Quality	Industrial Processes - Storage and Transfer	51
3	Georgia Department of Natural Resources	Bulk Gasoline Terminals	100
3	Georgia Department of Natural Resources	Gas Stations	96
3	Georgia Department of Natural Resources	Industrial Processes - Storage and Transfer	3
4	Knox County Department of Air Quality Management	Bulk Gasoline Terminals	100
4	Knox County Department of Air Quality Management	Gas Stations	100
4	Knox County Department of Air Quality Management	Industrial Processes - Storage and Transfer	2
4	Metro Public Health of Nashville/Davidson County	Gas Stations	14
4	Metro Public Health of Nashville/Davidson County	Industrial Processes - Storage and Transfer	49
5	Illinois Environmental Protection Agency	Gas Stations	100
5	Illinois Environmental Protection Agency	Industrial Processes - Storage and Transfer	31
5	Michigan Department of Environmental Quality	Bulk Gasoline Terminals	100
5	Michigan Department of Environmental Quality	Gas Stations	100
5	Michigan Department of Environmental Quality	Industrial Processes - Storage and Transfer	11
5	Ohio Environmental Protection Agency	Bulk Gasoline Terminals	0
6	Texas Commission on Environmental Quality	Bulk Gasoline Terminals	100
7	Iowa Department of Natural Resources	Gas Stations	71
8	Utah Division of Air Quality	Bulk Gasoline Terminals	19
8	Utah Division of Air Quality	Gas Stations	69
8	Utah Division of Air Quality	Industrial Processes - Storage and Transfer	13
9	California Air Resources Board	Bulk Gasoline Terminals	25
9	California Air Resources Board	Gas Stations	100
9	California Air Resources Board	Industrial Processes - Storage and Transfer	91
9	Clark County Department of Air Quality and Environmental Management	Bulk Gasoline Terminals	49
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	Gas Stations	100
9	Washoe County Health District	Gas Stations	100
9	Washoe County Health District	Industrial Processes - Storage and Transfer	100
10	Alaska Department of Environmental Conservation	Bulk Gasoline Terminals	51

Region	Agency	Sector	VOC
10	Coeur d'Alene Tribe	Gas Stations	100
10	Coeur d'Alene Tribe	Industrial Processes - Storage and Transfer	100
10	Idaho Department of Environmental Quality	Gas Stations	66
10	Idaho Department of Environmental Quality	Industrial Processes - Storage and Transfer	100
10	Kootenai Tribe of Idaho	Gas Stations	100
10	Kootenai Tribe of Idaho	Industrial Processes - Storage and Transfer	100
10	Nez Perce Tribe	Gas Stations	100
10	Nez Perce Tribe	Industrial Processes - Storage and Transfer	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Gas Stations	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Industrial Processes - Storage and Transfer	100
10	Washington State Department of Ecology	Gas Stations	71

4.6.3 EPA-developed emissions for Stage 1 Gasoline Distribution

The detailed calculation approach used by the EPA to estimate emission from stage I gasoline distribution can be found on the 2014v2 Supplemental Data FTP site in the file "Stage I Gasoline Distribution for NEI v2.zip." In short, the EPA broke stage 1 gasoline emissions into six basic parts: 1) bulk terminals; 2) pipeline facilities; 3) bulk plants; 4) tank trucks; and 5) service stations (which can be further subdivided into Filling and Breathing & Emptying).

For bulk terminals and pipeline facilities, there are no activity-based VOC emission factors, so estimates from 1998 developed in support of the Gasoline Distribution MACT standard [ref 1] are scaled up to 2014, based on a ratio of the national volume of wholesale gasoline supplied. This information comes from the Petroleum Supply Annual, provided by the Energy Information Administration [ref 2].

For bulk plants, the activity information comes from the national volume of gasoline passing through bulk plants in 2014, which is assumed to be nine percent of total gasoline consumption. The gasoline consumption data was obtained from the Energy Information Administration's Petroleum Navigator website.

The activity data for tank trucks in transit also comes from the EIA's Petroleum Navigator website, and the gasoline throughput for tank trucks was computed by multiplying the county-level gasoline consumption estimates by a factor of 1.09, to account for gasoline that is transported more than once in each area (for example, transported from bulk terminal to bulk plant and then from bulk plant to service station [ref 3].

Underground storage tank breathing and emptying, as well as filling operations, depend on more complicated information that takes into account vapor pressures, average temperatures, and molecular weights, and relies on the MOtor Vehicle Emission Simulator (MOVES) for some of the inputs for these equations [ref 4].

4.6.3.1 *Point Source Subtraction*

Point source subtraction removes the activity and emissions associated with point source contributions to the total activity. For example, emissions from transfer stations are included in the S/L/T agency submissions for those transfer stations with large enough emissions to trigger point source reporting (see Section 1.5). The EPA performed the point source subtraction of S/L/T agency point inventory emissions and uploaded the results to the 2014EPA_NONPOINT_V2 dataset. The crosswalk for point to nonpoint sources that EPA used is included in the Access database in the zipped file noted in Section 4.6.3 above.

4.6.3.2 *EPA Tagged Data*

The results of the nonpoint survey showed that many states submit several SCCs for gasoline distribution in the point sector of their inventories. All the EPA nonpoint data were therefore tagged for these S/L/T-SCC combinations, shown in Table 4-33, to avoid double counting emissions.

Table 4-33: S/L/Ts and SCCs where EPA Gasoline Stage 1 Distribution estimates were tagged out

Tag Reason	SCC	S/L/T agencies
All in Point	2501050120 (bulk gas terminals)	Chattanooga, CO, IL, KY, ME, Maricopa County, MS, NE, OR, Washoe County, WY
	2501055120 (bulk plants)	Chattanooga, CO, IL, KY, ME, Maricopa County, MD, MS, NE, NH, OR, RI, Washoe County, WY
	2501060051, 52, 53, and 201 (gas service stations stage 1)	CO
	2505030120 (truck)	CA, NE
	2505040120 (pipeline)	NE
Do not have this type of source	2501050120 (bulk gas terminals)	NJ
	2501055120 (bulk plants)	AK, NJ
	2501060052 (splash filling)	Chattanooga, Knox County, OH, UT, VA
	2501060053 (balanced submerged)	Chattanooga, OH
	2505030120 (truck)	Washoe County
	2505040120 (pipeline)	CO, DE, MD, RI, Washoe County
Use different SCCs	2501055120 (bulk plants)	CA

4.6.4 EPA-developed emissions for Aviation Gasoline

The detailed calculation approach used by EPA to estimate emission from stage I gasoline distribution can be found on the 2014v2 Supplemental Data FTP site in the file "Aviation Gasoline v4.1_2016-11-11.zip". The amount of aviation gasoline consumed by each state in 2014 was obtained from the Energy Information Administration (EIA) State Energy Data System (SEDS) [ref 5]. This information was used to calculate county-level emissions estimates for one criteria pollutant and ten HAPs. More information on the assumptions (e.g., number of bulk plant processes) and details on emission factors can be found in the zip file documentation.

4.6.5 State Submittals for Aviation Gasoline

Only a handful of states submitted to these SCCs for Aviation Gasoline. These states were Delaware, Illinois, Maryland, Maine, Michigan, New Jersey and Utah. A few states indicated in the Nonpoint Survey that the EPA should supplement their submissions with EPA data, with the reasoning that they do not have this type of source. These S/L/Ts were New York, Chattanooga, Tennessee and Knox County, Tennessee. In addition, California and Colorado indicated that all their emissions for aviation gasoline are covered in the point source category of their submissions, so no EPA estimates were included in the NEI for these states.

4.6.6 Updates for 2014v2

The 2014v2 updates are limited to the following:

- Updated County Business Patterns and State-level employment data to 2014 US Census Bureau data, used in Aviation Gasoline and Gas Distribution estimates.
- Updated the “FillingTechnology” table for gasoline distribution to account for International Fire Code (IFC) adoptions by states and counties. For counties that have adopted the IFC, it is assumed that there is no (0%) splash filling. Counties that had splash filling were moved to submerged.

4.6.7 References for nonpoint gasoline distribution

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3. Cavalier, Julia, MACTEC, Inc., personal communication, "RE: Percentage of Gasoline Transported Twice By Truck," with Stephen Shedd, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Standards Division, July 6, 2004.
4. U.S. Environmental Protection Agency, The MOVES Team, “Gallons of gasoline consumed in each county by market share of RVP (fuel formulation) by month for calendar year 2011,” CountyGallons2011.zip, created February 2016.
5. Energy Information Administration. State Energy Data System (SEDS): 1960-2014 (complete). Consumption in Physical Units. U.S. Department of Energy. Washington, D.C. December 2016.

4.7 Commercial Cooking

4.7.1 Sector description

Commercial cooking refers to the cooking of meat, including steak, hamburger, poultry, pork, and seafood, and french fries on five different cooking devices: chain-driven (conveyorized) charbroilers, underfired charbroilers, deep-fat fryers, flat griddles and clamshell griddles. Table 4-34 lists the SCCs in the commercial cooking sector; EPA estimates emissions for all SCCs in this sector. The SCC level 1 and 2 descriptions are “Industrial Processes; Food and Kindred Products: SIC 20” for all SCCs.

Table 4-34: Source Classification Codes used in the Commercial Cooking sector

SCC	SCC Description, level 3	SCC Descriptions, level 4
2302002100	Commercial Cooking – Charbroiling	Conveyorized Charbroiling
2302002200	Commercial Cooking – Charbroiling	Under-fired Charbroiling
2302003000	Commercial Cooking – Frying	Deep Fat Frying
2302003100	Commercial Cooking – Frying	Flat Griddle Frying
2302003200	Commercial Cooking – Frying	Clamshell Griddle Frying

4.7.2 Sources of data

The agencies listed in Table 4-35 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-35: Percentage of Commercial Cooking $PM_{2.5}$ and VOC emissions submitted by reporting agency

Region	Agency	$PM_{2.5}$	VOC
2	New Jersey Department of Environment Protection	100	100
2	New York State Department of Environmental Conservation	100	100
3	Delaware Department of Natural Resources and Environmental Control	100	100
3	Maryland Department of the Environment	100	100
4	Knox County Department of Air Quality Management	100	100
5	Illinois Environmental Protection Agency	100	100
6	Texas Commission on Environmental Quality	100	100
9	California Air Resources Board	5	54
9	Washoe County Health District	100	100
10	Coeur d'Alene Tribe	100	100
10	Idaho Department of Environmental Quality	100	100
10	Kootenai Tribe of Idaho	100	100
10	Nez Perce Tribe	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	100	100

4.7.3 EPA-developed emissions for commercial cooking

The approach for estimating emissions from commercial cooking in 2014 consists of three general steps, as follows:

- Determine county-level activity, i.e., the number of restaurants in each county in 2014;
- Determine the fraction of restaurants with commercial cooking equipment, the average number of units of each type of equipment per restaurant, and the average amount of food cooked on each type of equipment; and
- Apply emission factors to each type of food for each type of commercial cooking equipment.

More information on the estimation methods can be found in the documentation for commercial cooking, entitled "Commercial Cooking_v1.5_2017-05-26.zip" on the 2014v2 Supplemental Data FTP site.

4.7.3.1 *Activity Data: updated for 2014v2*

Data on the number of restaurants in each county are available from the U.S. Census Bureau County Business Patterns database [ref 1], which reports the number of restaurants (categorized by NAICS code) in each county. In general, our approach for the 2014 NEI was to grow the detailed activity data from the 2002 NEI, and so we will provide more information about the 2002 NEI approach here.

The 2002 NEI is the most recent inventory for which we estimated emissions from commercial cooking using restaurant-level data rather than population data. The 2002 approach used the Dun and Bradstreet industry database, which contains more specific information on the type of restaurant in each county. The approach for the 2002 NEI identifies five specific categories of restaurants that are likely to have the equipment that matches the source categories for commercial cooking emissions, including: ethnic food restaurants, fast food restaurants, family restaurants, seafood restaurants, and steak & barbecue restaurants. Because Dun and Bradstreet data for 2014 were not readily available, the number of restaurants in each county was estimated using a two-step process. First the number of restaurants in 2002 was estimated using the following equation:

$$REST_{i,2002} = \frac{E_{ijmn,2002}}{FRAC_j \times UNITS_j \times FOOD_{jm} \times EF_{jmn}} \qquad (1)$$

where:

$REST_{i,2002}$	=	the total number of restaurants in county *i* in 2002
$E_{ijmn,2002}$	=	the emissions of pollutant *n* from food *m* cooked on source category *j* in county *i* in 2002, as reported in the National Emissions Inventory
$FRAC_j$	=	the fraction of restaurants in those categories that have equipment in source *j*
$UNITS_j$	=	the average number of units of source category *j* in each restaurant
$FOOD_{jm}$	=	the average amount of food *m* cooked on source category *j*
EF_{jmn}	=	the emission factor for pollutant *n* from food *m* cooked on source category *j*

The values of $FRAC_i$, $UNITS_i$, and $FOOD_i$, came from Potepan [ref 2]. The emission factors are from an E.H. Pechan and Associates memorandum [ref 3].

Next, a growth factor based on the change in the number of restaurants in each county between 2002 and 2014 was generated using data from the U.S. Census Bureau County Business Patterns database for NAICS code 722511 (*Full-Service Restaurants*) and NAICS code 722513 (*Limited-Service Restaurants)*. For example, if the number of restaurants in a county increased from 100 to 125 between 2002 and 2014, the growth factor would be 1.25; in some cases, the number of restaurants decreased, and the growth factor was less than 1. This growth factor was multiplied by the number of restaurants in each county in 2002, as shown in equation 2, to estimate the number of restaurants in 2014:

$$REST_{i,2014} = REST_{i,2002} \times GF_i \qquad (2)$$

where GF_i is the growth factor for county *i*.

4.7.3.2 *Emission Factors*

Emission factors for each type of food on each type of commercial cooking equipment (EF_{jmn}) came from a technical memorandum developed by E.H. Pechan and Associates [ref 2]. This information remains the most complete catalog of emission factors for commercial cooking; a recent review of the literature on emissions from cooking revealed no new studies with a similar breadth of pollutants analyzed [ref 4]. The PM emission factors from E.H. Pechan and Associates only contain primary PM. The emission factors for filterable PM were derived by applying ratios to primary PM (Table 4-36). The condensable particulate matter condensable PM emission factors were derived by subtracting PM10-FIL from PM_{10}-PRI.

HAP emissions from deep-fat frying, flat griddle frying, and clamshell griddle frying are estimated using speciation factors from EPA's SPECIATE database [ref 5]. These speciation factors are provided in the documentation for Commercial Cooking, entitled "Commercial Cooking_v1.5_2017-05-26.zip" on the 2014v2 Supplemental Data FTP site.

Table 4-36: Ratio of filterable particulate matter to primary particulate matter for $PM_{2.5}$ and PM_{10} by SCC

Cooking Device	SCC	PM25-FIL / PM25-PRI	PM10-FIL / PM10-PRI
Conveyorized Charbroiling	2302002100	0.00321	0.00331
Underfired Charbroiling	2302002200	0.00287	0.00297
Flat Griddle Frying	2302003100	0.00201	0.00264
Clamshell Griddle Frying	2302003200	0.00241	0.00283

4.7.3.3 *Emissions*

After estimating the number of restaurants in 2014 using Equation 2, the amount of emissions in 2014 was determined by rearranging Equation 1, as shown in Equation 3:

$$E_{ijmn,2014} = REST_{i,2014} \times FRAC_j \times UNITS_j \times FOOD_{jm} \times EF_{jmn} \qquad (3)$$

where $E_{ijmn,2014}$ is the emissions of pollutant *n* from food *m* cooked on commercial equipment *j* in county *i* in 2014.

The fraction of restaurants with commercial cooking equipment ($FRAC_j$), the average units of equipment per restaurant ($UNITS_j$), and the average amount of each type of food cooked on each type of equipment ($FOOD_j$), were obtained from Potepan (2001) [ref 2]. Potepan reports the fraction of restaurants with commercial cooking equipment subcategorized by restaurant types: ethnic food restaurants, fast food restaurants, family restaurants, seafood restaurants, and steak & barbecue restaurants). To use these data, we calculated a weighted average of these fractions to determine an overall fraction of the number of all restaurants across all five subcategories that utilize commercial cooking equipment. Furthermore, because Potepan reports that 31% of all restaurants fall into one of those five subcategories, the weighted averages were multiplied by 0.31 to determine the fraction of all restaurants in each county with commercial cooking equipment. These numbers are reported in Table 4-37. The percentage of restaurants with under-fired charbroilers (12.5%) is similar to a more recent survey in North Carolina [ref 6], which found that 13% of surveyed restaurants employed charbroilers. The North Carolina survey did not include the other types of commercial cooking equipment reported here.

Table 4-37: Fraction of restaurants with source category equipment and average number of units per restaurant

Source Category	SCC	Percent of Restaurants with Equipment ($FRAC_j$)	Average Number of Units Per Restaurant ($UNITS_j$)
Conveyorized Charbroiling	2302002100	3.6%	1.3
Under-fired Charbroiling	2302002200	12.5%	1.5
Deep Fat Frying	2302003000	28.0%	2.5
Flat Griddle Frying	2302003100	18.4%	1.6
Clamshell Griddle Frying	2302003200	2.8%	1.7

Potepan also estimated the average annual amount of food cooked on each type of commercial cooking equipment ($FOOD_j$). These numbers are reported in Table 4-38 below. The amount of french fried potatoes cooked in deep-fat fryers was estimated by dividing the total weight of frozen potatoes utilized in domestic food service (6.9 million tons, [ref 7]) by the estimated number of deep-fryers in the United States (303,918 deep-fryers).

Table 4-38: Average amount of food cooked per year (tons/year) on each type of Commercial Cooking equipment

Food	Conveyorized Charbroiling	Under-fired Charbroiling	Deep Fat Frying	Flat Griddle Frying	Clamshell Griddle Frying
Steak	6.1	4.7	4.7	4.3	2.4
Hamburger	20.7	7.0	7.1	9.4	34.2
Poultry	10.7	8.4	14.9	5.2	5.7
Pork	1.5	3.8	1.5	2.9	3.1
Seafood	3.1	3.7	4.1	2.4	16.4
Other	-	1.1	7.1	1.5	-
Potatoes	-	-	21.3	-	-

4.7.3.4 *Example Calculations*

Determining the Number of Restaurants in Each County in 2002

$$REST_{i,2002} = \frac{E_{ijmn,2002}}{FRAC_j \times UNITS_j \times FOOD_{jm} \times EF_{jmn}}$$

$$203 \text{ restaurants } = \frac{8.76_{PM25,Underfired-Charbroilers}}{0.125 \times 1.54 \times 7.02 \times 0.032}$$

Emissions of $PM_{2.5}$ from underfired charbroilers in county *i* in 2002 were 8.76 tons. To determine the number of restaurants that generated these emissions in 2002, the emissions are divided by the fraction of restaurants that use underfired charbroilers (0.125), the average number of underfired charbroilers used at each restaurant (1.54), the average amount of hamburger cooked on each underfired charbroiler (7.02 tons/year), and the emission factor for $PM_{2.5}$ from hamburger cooked on underfired charbroilers (0.032 tons $PM_{2.5}$ per ton of hamburger). The result shows that there were 203 restaurants in county *i* in 2002. This process is repeated for each SCC (Table 4-34) and each type of food (Table 4-38) in each county.

Determining the Number of Restaurants in Each County in 2014

Using the estimated number of restaurants in 2002, the number of restaurants in 2014 was determined by employing a growth factor based on the change in the number of restaurants between 2002 and 2014 as determined by the U.S. Census Bureau County Business Statistics Database [ref 1].

$$REST_{i,2014} = REST_{i,2002} \times GF_i$$

$$235 \text{ restaurants} = 203 \text{ restaurants} \times 1.16$$

There were 203 restaurants estimated to be in county *i* in 2002. Data from the U.S. Census Bureau show that there was a 16% increase in the number of restaurants in county *i* between 2002 and 2014. The growth factor (1.16) was multiplied by 203 to estimate that there were 235 restaurants in county *i* in 2014. Note that the actual number of restaurants in 2014 as determined from the U.S. Census Bureau County Business Statistics database is not equal to $REST_{i,2014}$ as determined by the equation above because the emissions from the 2002 NEI were calculated using activity data from the Dun and Bradstreet database, rather than the U.S. Census Bureau County Business Statistics database.

Determining the Emissions in 2014

The emissions in 2014 were determined using the following equation:

$$E_{ijmn,2014} = REST_{i,2014} \times FRAC_j \times UNITS_j \times FOOD_{jm} \times EF_{jmn}$$

$$10.16\ tons\ PM25 = 235 \times 0.125 \times 1.54 \times 7.02 \times 0.032$$

There were 235 restaurants in county *i* in 2014. This was multiplied by the fraction of restaurants that use underfired charbroilers (0.125), the average number of underfired charbroilers used at each restaurant (1.54), the average amount of hamburger cooked on each underfired charbroiler (7.02 tons/year), and the emission factor for $PM_{2.5}$ from hamburger cooked on underfired charbroilers (0.032 tons $PM_{2.5}$ per ton of hamburger). The result shows that the emissions of $PM_{2.5}$ in county *i* were 10.16 tons in 2014.

4.7.3.5 *Changes from 2011 Methodology*

The growth factors were updated using data on the number of restaurants in 2002 and 2014 from the U.S. Census Bureau County Business Statistics Database.

4.7.3.6 *Puerto Rico and US Virgin Islands Emissions Calculations*

Insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands; therefore, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the U.S. Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and U.S. Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.7.3.7 *EPA tags and corrections made for v2*

Some states indicated on their nonpoint survey that they did not have one or more of the sources EPA estimates in this sector, so we did not use EPA estimates for these SCCs in the NEI. These states (or territories) and SCCs are given in Table 4-39.

Table 4-39: State agencies that requested EPA tag out Commercial Cooking sources

State	SCC	Description
Alaska	2302002100	Commercial Cooking – Charbroiling; Conveyorized Charbroiling
Alaska	2302002200	Commercial Cooking – Charbroiling; Under-fired Charbroiling
Nebraska	2302003200	Commercial Cooking – Frying; Clamshell Griddle Frying
Puerto Rico	2302002100	Commercial Cooking – Charbroiling; Conveyorized Charbroiling
Puerto Rico	2302003200	Commercial Cooking – Frying; Clamshell Griddle Frying

4.7.4 References for commercial cooking

1. United States Census Bureau, 2014 County Business Patterns, accessed August 2016
2. Potepan, M. 2001. Charbroiling Activity Estimation. Public Research Institute, report for the California Air Resources Board and the California Environmental Protection Agency, accessed October 2015

3. E.H. Pechan and Associates. 2003. Methods for Developing a National Inventory for Commercial Cooking Processes: Technical Memorandum, accessed October 2015
4. Abdullahi, K.L, J.M. Delgado-Saborit, and R.M. Harrison. 2013. Emissions and indoor concentrations of particulate matter and its specific chemical components from cooking: a review. Atmospheric Environment, 71: 260–294.
5. U.S. Environmental Protection Agency. 2016. SPECIATE Database v4.5.
6. North Carolina Division of Air Quality. 2013. Supplement Section 110(a)(1) Maintenance Plan - February 2013, Appendix B, Section 4.4.4., accessed October 2015
7. United States Potato Board. 2011. Potato Sales and Utilization Estimates 2001-2010, accessed October 2015

4.8 Dust – Construction Dust

4.8.1 Sector description

Construction dust refers to residential and non-residential construction activity, which are functions of acreage disturbed for construction. This sector will be divided below when describing the calculation of EPA's emissions. Table 4-40 lists the nonpoint SCCs associated with this sector in the 2014 NEI. EPA estimates emissions for the indicated SCCs in the table. The SCC level 1 and 2 descriptions is "Industrial Processes; Construction: SIC 15 - 17" for all SCCs.

Table 4-40: SCCs in the 2014 NEI Construction Dust sector

EPA estimates?	SCC	SCC Level Three	SCC Level Four
	2311000000	Construction: SIC 15-17	All Processes: Total
Y	2311010000	Residential	Total
	2311010000	Residential	Vehicle Traffic
Y	2311020000	Industrial/Commercial/Institutional	Total
Y	2311030000	Road Construction	Total

4.8.2 Sources of data

The construction dust sector includes data from the S/L/T agency submitted data and the default EPA generated construction dust emissions. The agencies listed in Table 4-41 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-41: Percentage of Construction Dust $PM_{2.5}$ emissions submitted by reporting agency

Region	Agency	$PM_{2.5}$
1	New Hampshire Department of Environmental Services	4
2	New Jersey Department of Environment Protection	100
3	Delaware Department of Natural Resources and Environmental Control	100
3	Maryland Department of the Environment	100
5	Illinois Environmental Protection Agency	100
8	Utah Division of Air Quality	75
9	California Air Resources Board	100
9	Clark County Department of Air Quality and Environmental Management	100
9	Maricopa County Air Quality Department	100
9	Washoe County Health District	100

Region	Agency	$PM_{2.5}$
10	Coeur d'Alene Tribe	100
10	Idaho Department of Environmental Quality	100
10	Kootenai Tribe of Idaho	100
10	Nez Perce Tribe	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	100

4.8.3 EPA-developed emissions for residential construction

Emissions from residential construction activity are a function of the acreage disturbed and volume of soil excavated for residential construction. Residential construction activity is developed from data obtained from the U.S. Department of Commerce (DOC)'s Bureau of the Census.

4.8.3.1 *Activity Data*

There are two activity calculations performed for this SCC, acres of surface soil disturbed and volume of soil removed for basements.

Surface soil disturbed

The US Census Bureau has 2014 data for *New Privately Owned Housing Units Started by Purpose and Design* [ref 1] which provides regional level housing starts based on the groupings of 1 unit, 2-4 units, 5 or more units. A consultation with the Census Bureau in 2002 gave a breakdown of approximately 1/3 of the housing starts being for 2 unit structures, and 2/3 being for 3 and 4 unit structures. The 2-4 unit category was then divided into 2-units, and 3-4 units based on this ratio.

New Privately Owned Housing Units Authorized Unadjusted Units [ref 2] gives a conversion factor to determine the ratio of structures to units in the 5 or more unit category. For example, if a county has one 40-unit apartment building, the ratio would be 40/1. If there are 5 different 8 unit buildings in the same project, the ratio would be 40/5. Structures started by category are then calculated at a regional level.

Annual county building permit data were purchased from the US Census Bureau for 2014 [ref 3]. The 2014 County Level Residential Building Permit dataset has 2014 data to allocate regional housing starts to the county level. This results in county-level housing starts by number of units. Table 4-42 provides surface areas that were assumed disturbed for each unit type:

Table 4-42: Surface soil removed per unit type

Unit type	Surface acres disturbed
1-Unit	1/4 acre/structure
2-Unit	1/3 acre/structure
Apartment	1/2 acre/structure

The 3-4 unit category was considered to be an apartment. Multiplication of housing starts to soil removed results in number of acres disturbed for each unit category.

Basement soil removal

To calculate basement soil removal, the 2014 *Characteristics of New Single-Family Houses Completed, Foundation table* [ref 4] is used to estimate the percentage of 1 unit structures that have a basement (on the regional level). The county-level estimate of number of 1 unit starts is multiplied by the percent of 1 unit houses in the region that have a basement to get the number of basements in a county. Basement volume is calculated by assuming a 2000 square foot house has a basement dug to a depth of 8 feet (making 16,000 ft^3 per basement). An additional 10% is added for peripheral dirt bringing the total to 17,600 ft^3 (651.85 yd^3) per basement.

4.8.3.2 *Emission Factors*

Initial PM_{10} emissions from construction of single family, two-family, and apartments structures are calculated using the emission factors given in Table 4-43 [ref 5]. The duration of construction activity for houses is assumed to be 6 months and the duration of construction for apartments is assumed to be 12 months.

Table 4-43: Emission factors for Residential Construction

Type of Structure	Emission Factor	Duration of Construction
Apartments	0.11 tons PM_{10}/acre-month	12 months
2-Unit Structures	0.032 tons PM_{10}/acre-month	6 months
1-unit Structures with Basements	0.011 tons PM_{10}/acre-month	6 months
	0.059 tons PM_{10}/1000 cubic yards	
1-Unit Structures w/o Basements	0.032 tons PM_{10}/acre-month	6 months

Regional variances in construction emissions are corrected using soil moisture level and silt content. These correction parameters are applied to initial PM_{10} emissions from residential construction to develop the final emissions inventory.

To account for the soil moisture level, the PM_{10} emissions are weighted using the 30-year average precipitation-evaporation (PE) values from Thornthwaite's PE Index. Average precipitation evaporation values for each State were estimated based on PE values for specific climatic divisions within a State.

To account for the silt content, the PM_{10} emissions are weighted using average silt content for each county. EPA used the National Cooperative Soil Survey Microsoft Access Soil Characterization Database to develop county-level, average silt content values for surface soil [ref 6]. This database contains the most commonly requested data from the National Cooperative Soil Survey Laboratories including data from the Kellogg Soil Survey Laboratory and cooperating universities.

The equation for PM_{10} emissions corrected for soil moisture and silt content is:

$$Corrected\ E_{PM10} = Initial\ \mathrm{E}_{PM10} \times \frac{24}{PE} \times \frac{S}{9\%}$$

where:

Corrected EPM_{10} = PM_{10} emissions corrected for soil moisture and silt content,
PE = precipitation-evaporation value for each State,
S = % dry silt content in soil for area being inventoried.

Once PM_{10} adjustments have been made, PM25-FIL emissions are estimated by applying a particle size multiplier of 0.10 to PM10-FIL emissions [ref 7]. Primary PM emissions are equal to filterable emissions since there are no condensable emissions from residential construction.

4.8.3.3 *Example Calculation*

PM_{10} Emissions = $\sum(A_{unit} \times T_{construction} \times EF_{unit}) \times Adj_{PM}$

where:

A_{unit} = $HS_{Unit} \times SM_{Unit}$
HS_{Unit} = Regional Housing Starts x (county building permits/Regional building permits)
SM_{Unit} = Area or volume of soil moved for the given unit type
$T_{Construction}$ = Construction time (in months) for given unit type
EF_{Unit} = Unadjusted emission factor for PM_{10} for the given unit type
Adj_{PM} = PM Adjustment factor

As an example, in Beaufort County, North Carolina, 2010 acres disturbed and PM_{10} emissions from 1-unit housing starts without a basement are calculated as follows:

A_{unit} = 345,000x (142/342,534) x $0.921_{(\text{Fraction without basement})}$ * 0.25 acres/unit

= 131.72 units * 0.25 acres/unit = 32.9 acres

Adj_{PM} = (24/110.1) * (39.58/9) = 0.958

PM_{10} Emissions = (32.8 acres x 6 months x 0.032 tons PM_{10}/acre-month) x 0.958 = 6.06 tons

4.8.3.4 *Updates to 2011 Methodology*

The housing starts and soil removed were updated using the latest data from the U.S. Census Bureau. The county-level silt values were updated and are now based on soil sampling data contained in the National Cooperative Soil Survey Microsoft Access Soil Characterization Database. There were no updates in methodology between 2014v1 and 2014v2 for this sector.

4.8.3.5 *Puerto Rico and US Virgin Islands Emissions Calculations*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.8.3.6 *References for residential construction*

1. U.S. Census Bureau, New Privately Owned Housing Units Started by Purpose and Design in 2014, accessed September 2015.
2. U.S. Census Bureau, New Privately Owned Housing Units Authorized - Unadjusted Units for Regions, Divisions, and States, Annual 2014, Table 2au. Accessed September 2015.

3. U.S. Census Bureau, Annual Housing Units Authorized by Building Permits CO2014A, purchased September 2015.
4. U.S. Census Bureau, Type of Foundation in New One-Family Houses Completed, from Characteristics of New Single-Family Houses Completed, accessed September 2015.
5. Midwest Research Institute. Improvement of Specific Emission Factors (BACM Project No. 1). Prepared for South Coast Air Quality Management District. March 29, 1996.
6. U.S. Department of Agriculture, National Cooperative Soil Survey (NCSS) Soil Characterization Database, accessed September 2015.
7. Cowherd. C., J. Donaldson and R. Hegarty, Midwest Research Institute; D. Ono, Great Basin UAPCD Proposed Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors, accessed September 2015.

4.8.4 EPA-developed emissions for non-residential construction

Emissions from industrial/commercial/institutional (non-residential) construction activity are a function of the acreage disturbed for non-residential construction.

4.8.4.1 *Activity Data*

The activity data are the number of acres disturbed for non-residential construction and are estimated by multiplying the value of non-residential construction put in place by the number of acres disturbed per million dollars. *Annual Value of Construction Put in Place in the U.S* [ref 1] contains the 2014 national value of non-residential construction. The national value of non-residential construction put in place (in millions of dollars) was allocated to counties using county-level non-residential construction employment data (NAICS Code 2362) obtained from *County Business Patterns (CBP)* [ref 2]. Because some counties' employment data were withheld due to privacy concerns, the following procedure was adopted to estimate the number of county-level withheld employees:

1. State totals for the known county-level employees were subtracted from the total number of employees reported in the CBP state level file [ref 3]. This results in the total number of withheld employees in the state.
2. The midpoint of the range code was used as an initial estimate (so for instance in the 1-19 employees range, an estimate of 10 employees would be used) and a state total of the withheld employees was computed.
3. A ratio of estimated employees (Step 2) to withheld employees (Step 1) was then used to adjust the county-level estimates up or down so that the state total of adjusted estimates matches the state total of withheld employees (Step 1).

For the average acres disturbed per million dollars of non-residential construction, MRI reported a conversion factor of 2 acres/$1 million (in 1992 constant dollars) [ref 4]. EPA adjusted the 1992 conversion factor to 2014 using the Price Deflator (Fisher) Index of New Single-Family Houses Under Construction [ref 5]. By taking the ratio of the 2014 and 1992 Annual Index values and applying it to the 1992 factor, a value of 1.01 acres/$1 million (= 2/(113/57)) was estimated.

4.8.4.2 Emission Factors

Initial PM_{10} emissions from construction of non-residential buildings are calculated using an emission factor of 0.19 tons/acre-month [ref 6]. The duration of construction activity for non-residential construction is assumed to be 11 months. Since there are no condensable emissions, primary PM emissions are equal to filterable emissions. Once PM_{10}-xx emissions are developed, PM25-xx emissions are estimated by applying a particle size multiplier of 0.10 to PM_{10}-xx emissions [ref 7].

Regional variances in construction emissions are corrected using soil moisture level and silt content. These correction parameters are applied to initial PM_{10} emissions from non-residential construction to develop the final emissions inventory.

To account for the soil moisture level, the PM_{10} emissions are weighted using the 30-year average precipitation-evaporation (PE) values from Thornthwaite's PE Index. Average precipitation evaporation values for each State were estimated based on PE values for specific climatic divisions within a State [ref 4].

To account for the silt content, the PM_{10} emissions are weighted using average silt content for each county. EPA used the National Cooperative Soil Survey Microsoft Access Soil Characterization Database to develop county-level, average silt content values for surface soil [ref 8]. This database contains the most commonly requested data from the National Cooperative Soil Survey Laboratories including data from the Kellogg Soil Survey Laboratory and cooperating universities.

The equation for PM_{10} emissions corrected for soil moisture and silt content is:

$$Corrected\ E_{PM10} = Initial\ \mathrm{E}_{PM10} \times \frac{24}{PE} \times \frac{S}{9\%}$$

where:

Corrected E_{PM10} = PM_{10} emissions corrected for soil moisture and silt content,
PE = precipitation-evaporation value for each State,
S = % dry silt content in soil for area being inventoried.

Once PM_{10} adjustments have been made, $PM_{2.5}$ emissions are set to 10% of PM_{10}.

4.8.4.3 *Example Calculation*

$EmissionsPM_{10} = N_{Spending} \times (Emp_{county} / Emp_{National}) \times Apd \times EF_{Adj} \times M$

where:

$N_{Spending}$ = National spending on nonresidential construction (million dollars)
Emp_{county} = County-level employment in nonresidential construction
$Emp_{National}$ = National level employment in nonresidential construction
Apd = Acres per million dollars (national data)
EF_{Adj} = Adjusted PM_{10} emission factor (ton/acre-month)
M = duration of construction activity (months)

As an example, in Grand Traverse County, Michigan, 2014 acres disturbed and PM_{10} emissions from non-residential construction are calculated as follows:

$EmissionsPM_{10}$ = 347,666 x $\$10^6$ x (103/560,616) x 1.01 acres/$\$10^6$ x EF_{Adj} x M

= 70 acres x 0.1073 ton/acre-month x 11 months

= 83 tons PM_{10}

where EF_{Adj} is calculated as follows:

EF_{Adj} = 0.19 ton/acre-month * (24/103.6 * 21.95/9)

= 0.1073 ton/acre-month

4.8.4.4 *Changes from 2011 and 2014v1 Methodology*

The Annual Value of Construction Put in Place, employment data and the acres/$ million conversion factors were updated using the latest (year 2014) data from the U.S. Census Bureau (from 2013 data in 2014v1). The county-level silt values were updated and are now based on soil sampling data contained in the National Cooperative Soil Survey Microsoft Access Soil Characterization Database.

4.8.4.5 *Puerto Rico and US Virgin Islands Emissions Calculations*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.8.4.6 *References for non-residential construction dust*

1. U.S. Census Bureau, Value of Construction Put in Place at a Glance, accessed September 2015.
2. U.S Census Bureau, County Business Patterns: 2014, *"Complete County File [14.4mb zip],"* accessed August 2016.
3. U.S. Census Bureau, County Business Patterns: 2014, *"Complete State File [10.0mb zip],"* accessed August 2016.
4. Midwest Research Institute. 1999. *Estimating Particulate Matter Emissions from Construction Operations, Final Report* (prepared for the Emission Factor and Inventory Group, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency).
5. U.S. Census Bureau, Price Deflator (Fisher) Index of New Single-Family Houses Under Construction, accessed September 2015.
6. Midwest Research Institute. Improvement of Specific Emission Factors (BACM Project No. 1). Prepared for South Coast Air Quality Management District. March 29, 1996.
7. Midwest Research Institute. Background Document for Revisions to Fine Fraction Rations Used for AP-42 Fugitive Dust Emission Factors, Proposed Fine Fraction Ratios*, Table 1 (prepared for Western Governors' Association)*.
8. U.S. Department of Agriculture, National Cooperative Soil Survey (NCSS) Soil Characterization Database, accessed September 2015.

4.8.5 EPA-developed emissions for road construction

Emissions from road construction activity are a function of the acreage disturbed for road construction. Road construction activity is developed from data obtained from the Federal Highway Administration (FHWA).

4.8.5.1 *Activity Data*

The Federal Highway Administration's *Highway Statistics, State Highway Agency Capital Outlay 2014, Table SF-12A* [ref 1], outlines spending by state in several different categories. For this SCC, the following columns are used: New Construction, Relocation, Added Capacity, Major Widening, and Minor Widening. These columns are also differentiated according to the following six classifications:

1. Interstate, urban
2. Interstate, rural
3. Other arterial, urban
4. Other arterial, rural
5. Collectors, urban
6. Collectors, rural

The State expenditure data are then converted to new miles of road constructed using $/mile conversions obtained from the Florida Department of Transportation (FLDOT) in 2014 [ref 2]. A conversion of $6.8 million/mile is applied to the urban interstate expenditures and a conversion of $3.8 million/mile is applied to the rural interstate expenditures. For expenditures on other urban arterial and collectors, a conversion factor of $4.1 million/mile is applied, which corresponds to all other projects. For expenditures on other rural arterial and collectors, a conversion factor of $2.1 million/mile is applied, which corresponds to all other projects.

The new miles of road constructed are used to estimate the acreage disturbed due to road construction. The total area disturbed in each state is calculated by converting the new miles of road constructed to acres using an acres disturbed/mile conversion factor for each road type as given in Table 4-44.

Table 4-44: Spending per mile and acres disturbed per mile by highway type

Road Type	Thousand Dollars per mile	Total Affected Roadway Width (ft)*	Acres Disturbed per mile
Urban Areas, Interstate	6,895	94	11.4
Rural Areas, Interstate	3,810	89	10.8
Urban Areas, Other Arterials	4,112	63	7.6
Rural Areas, Other Arterials	2,076	55	6.6
Urban Areas, Collectors	4,112	63	7.6
Rural Areas, Collectors	2,076	55	6.6
*Total Affected Roadway Width = (lane width (12 ft) * number of lanes) + (shoulder width * number of shoulders) + area affected beyond road width (25 ft)			

The acres disturbed per mile data shown in Table 4-44 are calculated by multiplying the total affected roadway width (including all lanes, shoulders, and areas affected beyond the road width) by one mile and converting the resulting land area to acres. Building permits [ref 3] are used to allocate the state-level acres disturbed by road construction to the county. A ratio of the number of building starts in each county to the total number of building starts in each state is applied to the state-level acres disturbed to estimate the total number of acres disturbed by road construction in each county.

4.8.5.2 *Emission Factors*

Initial PM_{10} emissions from construction of roads are calculated using an emission factor of 0.42 tons/acre-month [ref 4]. This emission factor represents the large amount of dirt moved during the construction of roadways, reflecting the high level of cut and fill activity that occurs at road construction sites. The duration of construction activity for road construction is assumed to be 12 months.

Regional variances in construction emissions are corrected using soil moisture level and silt content. These correction parameters are applied to initial PM_{10} emissions from road construction to develop the final emissions inventory.

To account for the soil moisture level, the PM_{10} emissions are weighted using the 30-year average precipitation-evaporation (PE) values from Thornthwaite's PE Index. Average precipitation evaporation values for each State were estimated based on PE values for specific climatic divisions within a State [ref 4].

To account for the silt content, the PM_{10} emissions are weighted using average silt content for each county. EPA used the National Cooperative Soil Survey Microsoft Access Soil Characterization Database to develop county-level, average silt content values for surface soil [ref 5]. This database contains the most commonly requested data from the National Cooperative Soil Survey Laboratories including data from the Kellogg Soil Survey Laboratory and cooperating universities.

The equation for PM_{10} emissions corrected for soil moisture and silt content is:

$$Corrected\ E_{PM10} = Initial\ \mathrm{E}_{PM10} \times \frac{24}{PE} \times \frac{S}{9\%}$$

where:

Corrected E_{PM10}	= PM_{10} emissions corrected for soil moisture and silt content,
PE	= precipitation-evaporation value for each State,
S	= % dry silt content in soil for area being inventoried.

Once PM_{10} adjustments have been made, $PM_{2.5}$ emissions are set to 10% of PM_{10}. Primary PM emissions are equal to filterable emissions since there are no condensable emissions from road construction.

4.8.5.3 *Example Calculation*

$Emissions PM_{10} = \sum(HD_{rt} \times MC_{rt} \times AC_{rt}) \times (HS_{County} / HS_{State}) \times EF_{Adj} \times M$

where:

HD_{rt}	= Highway Spending for a specific road type
MC_{rt}	= Mileage conversion for a specific road type
AC_{rt}	= Acreage conversion for a specific road type
HS_{County}	= Housing Starts in a given county
HS_{State}	= Housing Starts in a given State
EF_{Adj}	= Adjusted PM_{10} Emission Factor
M	= duration of construction activity

As an example, in 2014, in Newport County, Rhode Island, acres disturbed and PM_{10} emissions from urban interstate, urban other arterial, and urban collector road construction are calculated as follows:

$Emissions PM_{10} = \sum(HD_{rt} \times MC_{rt} \times AC_{rt}) \times (HS_{County} / HS_{State}) \times EF_{Adj} \times M$

= (\$14,255/\$6,895/mi x 11.4 acres/mi) * (185/952) + (\$1,304/\$4,112/mi x 7.6 acres/mi) * (185/952) + (\$7,144/\$4,112/mi x 7.6 acres/mi) * (185/952) x EF_{Adj} x M

= 7.59 acres x 0.35 ton/acre-month x 12 months

$= 32.06$ tons PM_{10}

where EF_{Adj} is calculated as follows:

EF_{Adj} = 0.42 ton/acre-month * (24/132 * 41.45/9)

= 0.35 ton/acre-month

4.8.5.4 *Updates to 2011 and 2014v1 Methodology*

The FHWA data on roadway spending were updated to 2014 (from 2008 for 2014v1). The data source for $/mile, total affected roadway width, and acres disturbed per mile for new road construction for interstate, other arterials, and collector roads was changed from the North Carolina DOT 2000 data, used in the 2011 methodology, to the 2014 Florida DOT data.

4.8.5.5 *Puerto Rico and US Virgin Islands Emissions Calculations*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.8.5.6 *References for road construction*

1. Federal Highway Administration, 2014 Highway Spending, accessed July 2016.
2. Florida DOT Cost Per Mile Models for 2014, accessed September 2015.
3. Annual Housing Units Authorized by Building Permits CO2014A, purchased from US Department of Census, September 2015.
4. Midwest Research Institute. Improvement of Specific Emission Factors (BACM Project No. 1). Prepared for South Coast Air Quality Management District. March 29, 1996.
5. U.S. Department of Agriculture, National Cooperative Soil Survey (NCSS) Soil Characterization Database, accessed September 2015.

4.9 Dust – Paved Road Dust

4.9.1 Sector description

The SCCs that belong to this sector are provided in Table 4-45. EPA estimates emissions for particulate matter for the first SCC in this table. Fugitive dust emissions from paved road traffic were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there are no PM-CON emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL emissions.

Table 4-45: SCCs in the 2014 NEI Paved Road Dust sector

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2294000000	Mobile Sources	Paved Roads	All Paved Roads	Total: Fugitives
2294000002	Mobile Sources	Paved Roads	All Paved Roads	Total: Sanding/Salting - Fugitives

4.9.2 Sources of data

The paved road dust sector includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-46 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector.

Table 4-46: Percentage of Paved Road Dust $PM_{2.5}$ emissions submitted by reporting agency

Region	Agency	S/L/T	$PM_{2.5}$
1	Massachusetts Department of Environmental Protection	State	100
1	New Hampshire Department of Environmental Services	State	100
2	New Jersey Department of Environment Protection	State	100
2	New York State Department of Environmental Conservation	State	100
3	Delaware Department of Natural Resources and Environmental Control	State	100
3	Maryland Department of the Environment	State	100
8	Northern Cheyenne Tribe	Tribe	100
8	Utah Division of Air Quality	State	100
9	California Air Resources Board	State	100
9	Clark County Department of Air Quality and Environmental Management	Local	100
9	Maricopa County Air Quality Department	Local	100
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	Tribe	100
9	Washoe County Health District	Local	100
10	Coeur d'Alene Tribe	Tribe	100
10	Idaho Department of Environmental Quality	State	100
10	Kootenai Tribe of Idaho	Tribe	100
10	Nez Perce Tribe	Tribe	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100
10	Washington State Department of Ecology	State	100

4.9.3 EPA-developed emissions for paved road dust

Uncontrolled paved road emissions were calculated at the county level by roadway type and year. This was done by multiplying the county/roadway class paved road vehicle miles traveled (VMT) by the appropriate paved road emission factor. Next, control factors were applied to the paved road emissions in PM_{10} nonattainment and maintenance status counties. Emissions by roadway class were then totaled to the county level for reporting in the NEI. The following provides further details on the emission factor equation, determination of paved road VMT, and controls.

4.9.3.1 *Emission Factors*

Re-entrained road dust emissions for paved roads were estimated using paved road VMT and the emission factor equation from AP-42 [ref 1]:

$$E = [k\times(sL)^{0.91}\times(W)^{1.02}]$$

where:

E = paved road dust emission factor (g/VMT)
k = particle size multiplier (g/VMT)

sL = road surface silt loading (g/ m^2) (dimensionless in eq.)
W = average weight (tons) of all vehicles traveling the road (dimensionless in eq.)

The uncontrolled PM10-PRI/-FIL and PM25-PRI/-FIL emission factors are provided in the tab “Emission Factors” of the calculation workbook by county and roadway class. They are provided without utilizing any precipitation correction.

The particle size multipliers for both PM10-PRI/-FIL and PM25-PRI/-FIL for paved roads came from AP-42.

Paved road silt loadings were assigned to each of the fourteen functional roadway classes (seven urban and seven rural) based on the average annual traffic volume of each functional system by county [ref 2]. The silt loading values per average daily traffic volume come from the ubiquitous baseline values from Section 13.2.1 of AP-42. Average daily traffic volume (ADTV) was calculated by dividing an estimate of VMT by functional road length and then by 365. State FHWA road length by functional road type data was broken down to the county level by multiplying by the ratio of county VMT to state VMT for each FHWA road type.

To better estimate paved road fugitive dust emissions, the average vehicle weight was estimated by road type for each county in the U.S. based on the 2011 VMT by vehicle type. The VMT for each vehicle type (per MOVES road type and county) was divided by the sum of the VMT of all vehicle types for the given road type in each county. This ratio was multiplied by the vehicle type mass (see Table 4-47) and summed to road type for each county to calculate a VMT-weighted average vehicle weight for each county/road type combination in the database. The VMT-weighted average vehicle weight by MOVES vehicle type was converted to FWHA vehicle type using the crosswalk in Table 4-48 to be used in the emission factor equation above.

Table 4-47: Average vehicle weights by FWHA vehicle class

MOVES Vehicle Type	Source Mass (tons)
Motorcycle	0.285
Passenger Car	1.479
Passenger Truck	1.867
Light Commercial Truck	2.0598
Intercity Bus	19.594
Transit Bus	16.556
School Bus	9.070
Refuse Truck	23.114
Single Unit Short-haul Truck	8.539
Single Unit Long-haul Truck	6.984
Motor Home	7.526
Combination Short-haul Truck	22.975
Combination Long-haul Truck	24.601

Table 4-48: MOVES and FWHA vehicle type crosswalk

MOVES Road Type Description	FWHA Road Type
Rural Restricted Access	Rural Interstate
Rural Unrestricted Access	Rural Principal Arterial
Rural Unrestricted Access	Rural Minor Arterial
Rural Unrestricted Access	Rural Collector

MOVES Road Type Description	FWHA Road Type
Rural Unrestricted Access	Rural Local
Urban Restricted Access	Urban Interstate
Urban Unrestricted Access	Urban Principal Arterial
Urban Unrestricted Access	Urban Minor Arterial
Urban Unrestricted Access	Urban Collector
Urban Unrestricted Access	Urban Local

**Note: Other Freeways and Expressways were not included in the crosswalk, and so were assumed to be restricted access like Interstates.*

4.9.3.2 *Activity Data*

Total annual VMT estimates by county and roadway class were derived from a 2011 EPA Motor Vehicle Emission Simulator (MOVES) modelling run. To estimate the portion of the total VMT occurring on paved roads, first the VMT on unpaved roads were estimated using 2013 state-level FHWA data on length of unpaved roads by road type [ref 2] and 1996 ratios from FHWA (the last year these data were available) on average daily traffic volume per mile of unpaved road by road type [ref 3]. The estimated VMT on unpaved roads was subtracted from the total VMT from MOVES to estimate the VMT on paved roads.

4.9.3.3 *Allocation*

Total VMT from the MOVES modelling run is available at the county level. VMT on unpaved roads was estimated at the state level and allocated to the county level based on proportion of rural population. The allocated unpaved VMT was subtracted from the total VMT from MOVES to estimate the paved VMT.

4.9.3.4 *Controls*

Paved road dust controls were applied by county to urban and rural roads in serious PM_{10} nonattainment areas and to urban roads in moderate PM_{10} nonattainment areas. The assumed control measure is vacuum sweeping of paved roads twice per month. A control efficiency of 79% was assumed for this control measure [ref 4]. The assumed rule penetration varies by roadway class and PM_{10} nonattainment area classification (serious or moderate). The rule penetration rates are shown in Table 4-49. Rule effectiveness was assumed to be 100% for all counties where this control was applied.

Table 4-49: Penetration rate of Paved Road vacuum sweeping

PM_{10} Nonattainment Status	Roadway Class	Vacuum Sweeping Penetration Rate
Moderate	Urban Freeway & Expressway	0.67
Moderate	Urban Minor Arterial	0.67
Moderate	Urban Collector	0.64
Moderate	Urban Local	0.88
Serious	Rural Minor Arterial	0.71
Serious	Rural Major Collector	0.83
Serious	Rural Minor Collector	0.59
Serious	Rural Local	0.35

PM_{10} Nonattainment Status	Roadway Class	Vacuum Sweeping Penetration Rate
Serious	Urban Freeway & Expressway	0.67
Serious	Urban Minor Arterial	0.67
Serious	Urban Collector	0.64
Serious	Urban Local	0.88

Note that the controls were applied at the county/roadway class level, and the controls differ by roadway class. No controls were applied to interstate or principal arterial roadways because these road surfaces typically do not have vacuum sweeping. In the excel spreadsheet, the total emissions for all roadway classes were summed to the county level. Therefore, the emissions at the county level can represent several different control efficiency and rule penetration levels, and may include both controlled and uncontrolled emissions in the composite value.

4.9.3.5 *Meteorological Adjustment*

After controls were applied, emissions were summed to the county level and converted to tons prior to applying the meteorological adjustment. The meteorological adjustment accounts for the reduction on fugitive dust emissions via the impact of precipitation and other meteorological factors over each hour of the year and then averaged to an annual meteorological adjustment factor for each grid cell in each county, aggregated to a single county-level factor. For example, wet roads after it rains will result in significantly lower dust emissions. The county-level meteorological adjustment factors were developed by EPA based on the ratio of the unadjusted to meteorology-adjusted 2014v1 NEI county-level emissions from the SMOKE Flat Files. The county-level meteorological adjustment is a scalar between 0 and 1 that is multiplied by the estimated emissions, where lower-values/greater-reductions are typically found in areas with more frequent precipitation.

EPA inadvertently used the same meteorological adjustment factors for paved roads as unpaved roads. This is insignificant (less than 1% difference) for 99% of the counties because the gridded meteorology tends to vary little in each county, and it is only in (spatially) larger counties where unpaved and paved roads are allocated to many different grid cells where the potential for differences in county-averaged unpaved vs paved road meteorological adjustments can occur. The 33 counties in Table 4-50 are missing the adjustment factors for unpaved roads. All these counties are very urban and do not have any unpaved roads (e.g. DC, NYC counties, etc.). Because these counties were missing the adjustment for unpaved roads, we therefore did not apply a meteorological adjustment factor for the paved roads either.

Table 4-50: Counties where meteorological adjustment factors were not applied

FIPS	State	County Name
08031	CO	Denver
10001	DE	Kent
10003	DE	New Castle
10005	DE	Sussex
11001	DC	District of Columbia
18097	IN	Marion
34017	NJ	Hudson
34039	NJ	Union

36061	NY	New York
36081	NY	Queens
36085	NY	Richmond
42045	PA	Delaware
42101	PA	Philadelphia
51013	VA	Arlington
51510	VA	Alexandria city
51540	VA	Charlottesville city
51570	VA	Colonial Heights city
51580	VA	Covington city
51600	VA	Fairfax city
51610	VA	Falls Church city
51660	VA	Harrisonburg city
51670	VA	Hopewell city
51678	VA	Lexington city
51683	VA	Manassas city
51685	VA	Manassas Park city
51690	VA	Martinsville city
51710	VA	Norfolk city
51740	VA	Portsmouth city
51760	VA	Richmond city
51775	VA	Salem city
51830	VA	Williamsburg city
51840	VA	Winchester city

4.9.3.6 *Changes from the 2011 and 2014v1 Methodology*

The methodology described above contains several adjustments from the methodology used to compose the 2011 version. This is due in part to differences in data sources used to compile the inventory. In 2014v1, the factors used to adjust for precipitation were removed from the 2011 emission factor equation, and precipitation was not accounted for in the final inventory. However, as discussed in the previous section, the meteorological adjustment was re-introduced in the 2014v2 NEI.

The VMT data used in 2014 was based on EPA's MOVES model, whereas 2011 VMT data was based on its precursor NMIM model. For this reason, the vehicle types (and as such vehicle weights) changed from 2011 to 2014, though a VMT-weighted average vehicle weight was calculated by county and road type in both years. Furthermore, the VMT data used in 2011 was at the state-level, while the 2014 version had been further broken down into counties. For this reason, subsequent worksheets (including ADTV and silt loading) which were calculated at the state level in 2011 could be immediately calculated at the county level without further manipulation in 2014. The paved roadway types in the 2014 VMT dataset included two additional types not found in the 2011 version. The category "Rural: Other Freeways and Expressways" was newly added, and "Urban: Collector" was further broken down into major and minor collector roads.

4.9.3.7 *Puerto Rico and US Virgin Islands Emissions Calculations*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.9.4 References for paved road dust

1. United States Environmental Protection Agency, Office of Air Quality Planning and Standards. "Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.1, Paved Roads." Research Triangle Park, NC. January 2011.
2. U.S. Department of Transportation, Federal Highway Administration. Highway Statistics 2013. Office of Highway Policy Information. Washington, DC. September 2015.
3. Federal Highway Administration, Highway Statistics 1996, Table HM-67.
4. E.H. Pechan & Associates, Inc. "Phase II Regional Particulate Strategies; Task 4: Particulate Control Technology Characterization," draft report prepared for U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation. Washington, DC. June 1995.

4.10 Dust – Unpaved Road Dust

4.10.1 Sector description

There is only one SCC for this sector, provided in Table 4-51, in the 2014 NEI. EPA estimates emissions for particulate matter for this SCC. Fugitive dust emissions from unpaved road traffic were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there are no PM-CON emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL emissions.

Table 4-51: SCC in the 2014 NEI Unpaved Road Dust sector

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2296000000	Mobile Sources	Unpaved Roads	All Unpaved Roads	Total: Fugitives

4.10.2 Sources of data

The unpaved road dust sector includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-52 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-52: Percentage of Unpaved Road Dust $PM_{2.5}$ emissions submitted by reporting agency

Region	Agency	S/L/T	$PM_{2.5}$
1	Massachusetts Department of Environmental Protection	State	100
2	New Jersey Department of Environment Protection	State	100

Region	Agency	S/L/T	$PM_{2.5}$
3	Maryland Department of the Environment	State	100
8	Northern Cheyenne Tribe	Tribe	100
9	California Air Resources Board	State	100
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	Tribe	100
9	Washoe County Health District	Local	100
10	Washington State Department of Ecology	State	100

4.10.3 EPA-developed emissions for unpaved road dust

Uncontrolled unpaved road emissions were calculated at the county level by roadway type for the year 2014. This was done by multiplying the county/roadway class unpaved road vehicle miles traveled (VMT) by the appropriate unpaved road emission factor. Next, control factors were applied to the unpaved road emissions in PM_{10} nonattainment and maintenance area counties. Emissions by roadway class were then totaled to the county level and adjusted for meteorological conditions. Emissions were then aggregated to the state level and distributed to counties based on US Census rural and "like rural" population [ref 1]. The following provides further details on the emission factor equation, determination of unpaved road VMT, and controls.

4.10.3.1 *Emission Factors*

Re-entrained road dust emissions for unpaved roads were estimated using paved road VMT and the emission factor equation from AP-42 [ref 2]:

$$E = [k \times (s/12)^{1} \times (SPD/30)^{0.5}] / (M/0.5)^{0.2} - C$$

Where k and C are empirical constants given in Table 4-53, with:

E = unpaved road dust emission factor (lb/VMT)
k = particle size multiplier (lb/VMT)
s = surface material silt content (%)
SPD = mean vehicle speed (mph)
M = surface material moisture content (%)
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)

The uncontrolled emission factors without precipitation corrections are in the worksheet "Emission Factor Calculations" by county and roadway class.

Values used for the particle size multiplier and the 1980's vehicle fleet exhaust, brake wear, and tire wear are provided in Table 4-53, and come from AP-42 defaults.

Average State-level unpaved road silt content values, developed as part of the 1985 NAPAP Inventory, were obtained from the Illinois State Water Survey [ref 3]. Silt contents of over 200 unpaved roads from over 30 States were obtained. Average silt contents of unpaved roads were calculated for each sate that had three or more samples for that State. For States that did not have three or more samples, the average for all samples from all States was used as a default value. The silt content values are by State, and identifies if the values were based on a sample average or default value.

Table 4-53: Constants for unpaved roads re-entrained dust emission factor equation

Constant	PM25-PRI/PM25-FIL	PM_{10}-PRI/PM_{10}-FIL
k (lb/VMT)	0.18	1.8
C	0.00036	0.00047

Table 4-54 lists the speeds modeled on the unpaved roads by roadway class. These speeds were determined based on the average speeds modeled for onroad emission calculations and weighted to determine a single average speed for each of the roadway classes [ref 4] The roadway class "Urban collector" with an average speed of 20 mph was split into two sub-categories, "Urban major collector" and "Urban minor collector", to correspond to the roadway types found in the 2014 VMT data.

Table 4-54: Speeds modeled by roadway type on unpaved roads

Unpaved Roadway Type	Speed (mph)
Rural Minor Arterial	39
Rural Major Collector	34
Rural Minor Collector	30
Rural Local	30
Urban Other Principal Arterial	20
Urban Minor Arterial	20
Urban Major Collector	20
Urban Minor Collector	20
Urban Local	20

The value of 0.5 percent for M was chosen as the national default as sufficient resources were not available at the time the emissions were calculated to determine more locally-specific values for this variable.

4.10.3.2 *Activity Data*

Total annual VMT estimates by county and roadway class were derived from a 2008 NMIM run providing state-level estimates of VMT by road type and by road surface type.

Total annual VMT estimates by county and roadway class were derived from a 2014 MOVES run providing county-level estimates of total (paved and unpaved) VMT by road type. Unpaved VMT was calculated by multiplying total VMT in each county by a census region-level ratio of unpaved VMT to total VMT.

$$\frac{Unpaved\ VMT\ from\ Version\ 1_{by\ census\ region\ and\ road\ type}}{Total\ VMT\ from\ MOVES_{by\ census\ region\ and\ road\ type}}$$

Table 4-55 lists the census region-level ratios. These ratios were calculated based on the sum of the unpaved VMT in each census region in the EPA dataset calculated for the 2011 NEI divided by the sum of the total VMT in each census region. The origin of the unpaved/total split from the 2011 NEI was from data from FHWA from 1996 (the last year these data were available) [ref 5].

Table 4-55: Unpaved Ratios by Census Region and Road Type

Region	FHWA Road Type	Unpaved Ratio
Midwest Region	Rural Interstate	0.00E+00
Midwest Region	Rural Local	2.70E-01
Midwest Region	Rural Major Collector	7.18E-03
Midwest Region	Rural Minor Arterial	0.00E+00
Midwest Region	Rural Minor Collector	5.82E-02

Region	FHWA Road Type	Unpaved Ratio
Midwest Region	Rural Other Freeways and Expressways	0.00E+00
Midwest Region	Rural Other Principal Arterial	0.00E+00
Midwest Region	Urban Interstate	0.00E+00
Midwest Region	Urban Local	8.99E-02
Midwest Region	Urban Major Collector	3.88E-03
Midwest Region	Urban Minor Arterial	4.72E-04
Midwest Region	Urban Minor Collector	1.73E-01
Midwest Region	Urban Other Freeways and Expressways	0.00E+00
Midwest Region	Urban Other Principal Arterial	0.00E+00
Northeast Region	Rural Interstate	0.00E+00
Northeast Region	Rural Local	4.08E-02
Northeast Region	Rural Major Collector	1.29E-04
Northeast Region	Rural Minor Arterial	0.00E+00
Northeast Region	Rural Minor Collector	1.09E-03
Northeast Region	Rural Other Freeways and Expressways	0.00E+00
Northeast Region	Rural Other Principal Arterial	0.00E+00
Northeast Region	Urban Interstate	0.00E+00
Northeast Region	Urban Local	3.03E-03
Northeast Region	Urban Major Collector	3.71E-06
Northeast Region	Urban Minor Arterial	0.00E+00
Northeast Region	Urban Minor Collector	1.74E-04
Northeast Region	Urban Other Freeways and Expressways	0.00E+00
Northeast Region	Urban Other Principal Arterial	0.00E+00
South Region	Rural Interstate	0.00E+00
South Region	Rural Local	1.72E-01
South Region	Rural Major Collector	1.61E-03
South Region	Rural Minor Arterial	0.00E+00
South Region	Rural Minor Collector	1.63E-02
South Region	Rural Other Freeways and Expressways	0.00E+00
South Region	Rural Other Principal Arterial	0.00E+00
South Region	Urban Interstate	0.00E+00
South Region	Urban Local	3.17E-02
South Region	Urban Major Collector	9.23E-04
South Region	Urban Minor Arterial	3.12E-04
South Region	Urban Minor Collector	1.49E-02
South Region	Urban Other Freeways and Expressways	0.00E+00
South Region	Urban Other Principal Arterial	0.00E+00
West Region	Rural Interstate	0.00E+00
West Region	Rural Local	3.03E-01
West Region	Rural Major Collector	7.03E-03
West Region	Rural Minor Arterial	0.00E+00
West Region	Rural Minor Collector	1.23E-01
West Region	Rural Other Freeways and Expressways	0.00E+00
West Region	Rural Other Principal Arterial	0.00E+00
West Region	Urban Interstate	0.00E+00
West Region	Urban Local	6.13E-02
West Region	Urban Major Collector	3.26E-04

Region	FHWA Road Type	Unpaved Ratio
West Region	Urban Minor Arterial	1.20E-04
West Region	Urban Minor Collector	3.24E-03
West Region	Urban Other Freeways and Expressways	0.00E+00
West Region	Urban Other Principal Arterial	0.00E+00

4.10.3.3 *Allocation*

County level emissions were calculated by multiplying the county unpaved VMT (by road type) by the emission factors calculated in Section 4.10.3.1 and aggregating based on county and urban/rural classification.

4.10.3.4 *Controls*

The controls assumed for unpaved roads varied by PM_{10} nonattainment area classification and by urban and rural areas. On urban unpaved roads in moderate PM_{10} nonattainment areas, paving of the unpaved road was assumed and a control efficiency of 96 percent and a rule penetration of 50 percent were applied. Controls were not applied to rural unpaved roads in moderate nonattainment areas. Chemical stabilization, with a control efficiency of 75 percent and a rule penetration of 50 percent, was assumed for rural areas in serious PM_{10} nonattainment areas. A combination of paving and chemical stabilization, with a control efficiency of 90 percent and a rule penetration of 75 percent, was assumed for urban unpaved roads in serious PM_{10} nonattainment areas. In counties currently at maintenance status, controls were assumed based on the severity (moderate or serious) of their prior nonattainment status. Some counties had multiple partial areas with differing levels of nonattainment. In these cases, controls were assumed to be applied based on the most serious level of nonattainment found within a given county.

Note that the controls were applied at the county level, and the controls differ by urban vs. rural roadway class. In the final emissions table, the emissions for all roadway classes were summed to the county level. Therefore, the emissions at the county level can represent several different control effectiveness and rule penetration levels. However, the control efficiency and rule penetration values were reported in the Controlled Emissions worksheet at the county level for urban and rural roadways separately.

4.10.3.5 *Meteorological Adjustment*

After controls were applied, emissions were summed to the county level and converted to tons prior to applying the meteorological adjustment. The meteorological adjustment accounts for the reduction on fugitive dust emissions via the impact of precipitation and other meteorological factors over each hour of the year and then averaged to an annual meteorological adjustment factor for each grid cell in each county, aggregated to a single county-level factor. For example, wet roads after it rains will result in significantly lower dust emissions. The county-level meteorological adjustment factors were developed by EPA based on the ratio of the unadjusted to meteorology-adjusted 2014v1 NEI county-level emissions from the SMOKE Flat Files. The county-level meteorological adjustment is a scalar between 0 and 1 that is multiplied by the estimated emissions, where lower-values/greater-reductions are typically found in areas with more frequent precipitation.

EPA inadvertently used the same meteorological adjustment factors for paved roads as unpaved roads. This is insignificant (less than 1% difference) for 99% of the counties because the gridded meteorology tends to vary little in each county, and it is only in (spatially) larger counties where unpaved and paved roads are allocated to many different grid cells where the potential for differences in county-averaged unpaved vs paved road meteorological adjustments can occur. The 33 counties in Table 4-50 (see Section 4.9.3.5) are missing the adjustment factors for unpaved roads. All these counties are very urban and do not have any unpaved roads (e.g. DC, NYC counties, etc.). Because these counties were missing the adjustment for unpaved roads, we therefore did not apply a meteorological adjustment factor for the paved roads either.

4.10.3.6 *Emissions Redistribution Procedure*

Unpaved roads are generally not located in urban centers, such as New York City or Chicago, so emissions were redistributed away from these areas to reflect this. Emissions were summed to the state-level and redistributed back to the county level based on the proportion of county to state rural and "like-rural" population, according to the 2010 Census. "Like-rural" population is defined as the population of urbanized areas and urban clusters with population densities' equal to or less than the maximum rural population density value for all counties in the US.

4.10.3.7 *Changes from 2011 and 2014v1 Methodology*

The methodology described above contains several adjustments from the methodology used to compose the 2011 version. This is due in part to differences in data sources used to compile the inventory. In 2014v1, the factors used to adjust for precipitation were removed from the 2011 emission factor equation, and precipitation was not accounted for in the final inventory. However, as discussed in Section 4.10.3.5, the meteorological adjustment was re-introduced in the 2014v2 NEI. Also, in 2014v2, VMT was obtained from a MOVES run instead an NMIM run, and separated in paved and unpaved values based on census-region level ratios. Emissions were also redistributed based on rural and "like-rural" county population.

4.10.3.8 *Puerto Rico and US Virgin Islands Emissions Calculations*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.10.4 References for unpaved road dust

1. U.S. Census Bureau. 2010 Census Urban and Rural Classification and Urban Area Criteria.
2. United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.2, Unpaved Roads. Research Triangle Park, NC. January 2011.
3. W. Barnard, G. Stensland, and D. Gatz, Illinois State Water Survey, "Evaluation of Potential Improvements in the Estimation of Unpaved Road Fugitive Emission Inventories," paper 87-58.1, presented at the 80th Annual Meeting of the APCA. New York, New York. June 21-26, 1987
4. United States Environmental Protection Agency, 2011 National Emissions Inventory, version 2 Technical Support Document. Research Triangle Park, NC. August 2015.
5. Federal Highway Administration, Highway Statistics 1996, Table HM-67.

4.11 Fires -Agricultural Field Burning

4.11.1 Sector Description

Agricultural burning refers to fires that occur over lands used for cultivating crops and agriculture. Another term for this sector is crop residue burning. In past NEIs for this sector, it was exclusively limited to emissions resulting in the burning of crops. However, in the 2014 NEI, we have included grass/pasture burning SCCs into this sector. Thus, this sector includes both crop residue burning as well as grass/pasture burning.

4.11.2 Sources of data: revised for 2014v2

Table 4-56 shows, the agricultural field burning SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The leading SCC description is "Miscellaneous Area Sources; Agriculture Production - Crops - as nonpoint; Agricultural Field Burning - whole field set on fire;" for all SCCs in the table.

New SCCs were added to this sector compared to the 2011 NEI to house the emissions that occur on grassland/pastures/rangeland. In addition, SCCs were added to better describe the specific crops being burned, including fields in which two or more crops are burned.

Note that many general crops are included in the SCC 2801500000, and it also is the SCC to report into for "crops unknown." The new SCC (2801500170) was added for grass/pasture burning for this sector for the 2014 NEI. All of the SCCs for "double crops" are also new to the 2014 NEI, and EPA reported emission into these SCCs as part of the methods described below.

Table 4-56: Nonpoint SCCs with 2014 NEI emissions in the Agricultural Field Burning sector

SCC	Description	EPA	State	Tribe
2801500000	Unspecified crop type and Burn Method	X	X	
2801500100	Field Crops Unspecified		X	X
2801500111	Field Crop is Alfalfa: Headfire Burning		X	
2801500120	Field Crop is Asparagus: Burning Techniques Not Significant		X	
2801500141	Field Crop is Bean (red): Headfire Burning	X	X	X
2801500150	Field Crop is Corn: Burning Techniques Not Important	X	X	
2801500151	Double Crop Winter Wheat and Corn	X	X	
2801500152	Double Crop Corn and Soybeans	X	X	
2801500160	Field Crop is Cotton: Burning Techniques Not Important	X	X	
2801500170	Field Crop is Grasses: Burning Techniques Not Important	X	X	X
2801500171	Fallow	X	X	
2801500181	Field Crop is Hay (wild): Headfire Burning		X	X
2801500201	Field Crop is Pea: Headfire Burning		X	
2801500220	Field Crop is Rice: Burning Techniques Not Significant	X	X	
2801500250	Field Crop is Sugar Cane: Burning Techniques Not Significant	X	X	
2801500261	Field Crop is Wheat: Headfire Burning		X	X
2801500262	Field Crop is Wheat: Backfire Burning	X	X	
2801500263	Double Crop Winter Wheat and Cotton	X	X	
2801500264	Double Crop Winter Wheat and Soybeans	X	X	
2801500300	Orchard Crop Unspecified		X	
2801500320	Orchard Crop is Apple		X	X

SCC	Description	EPA	State	Tribe
2801500330	Orchard Crop is Apricot		X	X
2801500350	Orchard Crop is Cherry		X	X
2801500360	Orchard Crop is Citrus (orange, lemon)		X	
2801500390	Orchard Crop is Nectarine		X	X
2801500400	Orchard Crop is Olive		X	
2801500410	Orchard Crop is Peach		X	X
2801500420	Orchard Crop is Pear		X	X
2801500430	Orchard Crop is Prune		X	X
2801500500	Vine Crop Unspecified		X	X
2801500600	Forest Residues Unspecified		X	

The agencies listed in Table 4-57 submitted $PM_{2.5}$ emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%). Only Idaho submitted revised estimates between 2014v1 and 2014v2.

Table 4-57: Percentage of agricultural fire/grass-pasture burning $PM_{2.5}$ emissions submitted by reporting agency

Region	Agency	S/L/T	$PM_{2.5}$
2	New Jersey Department of Environment Protection	State	98
4	Florida Department of Environmental Protection	State	100
4	Georgia Department of Natural Resources	State	100
4	South Carolina Department of Health and Environmental Control	State	100
5	Illinois Environmental Protection Agency	State	100
5	Indiana Department of Environmental Management	State	94
7	Iowa Department of Natural Resources	State	100
9	Arizona Department of Environmental Quality	State	24
9	California Air Resources Board	State	100
9	Hawaii Department of Health Clean Air Branch	State	100
10	Coeur d'Alene Tribe	Tribe	100
10	Idaho Department of Environmental Quality	State	66
10	Kootenai Tribe of Idaho	Tribe	100
10	Nez Perce Tribe	Tribe	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100
10	Washington State Department of Ecology	State	98

When we created the 2014v2 NEI, the S/L/T data had hierarchy over the EPA data (developed as described in the next section) for all CAP submissions. As such, S/L/T CAP emissions were carried forth from the 2014v1 inventory and no backfilling with EPA data was done. Additionally, in going from 2014v1 to 2014v2, only the state of Idaho revised their CAP emissions, and that data was used in 2014v2. Any “zero” submissions were left as zero in the 2014v1 NEI for those counties and pollutants. For HAPs, due to many failed QA checks using a mix of EPA and SLT-submitted VOC-HAP data in 2014v1, EPA used its HAP augmentation factors (as available in EIS) on a state by state basis, applying those HAP VOC fractions to VOC emissions submitted by the state at a county level to develop the 2014v2 VOC-HAP inventory for this sector. If there was no VOC submitted by the SLT, then the corresponding VOC estimated using EPA methods was used. For the States of Florida and Louisiana, robust state-specific HAP augmentation factors were not available; thus, national average VOC-HAP augmentation factors were used to estimate the VOC HAPs. Thus, no VOC-HAPs submitted by any SLTs were used in the 2014v2 inventory for this sector (all SLT-submitted HAPs in 2014v1 were removed). Any PM-based HAPs submitted by the SLTs were retained as submitted, no further augmentation was done on those HAPs. The actual EPA-data based ratios provided along with all the other HAP augmentation ratios can be accessed in EIS.

4.11.3 EPA-developed emissions for agricultural field burning

In the 2008 NEI, crop residue emission estimates were developed using satellite detects occurring over land types classified as "agricultural" and uncertain field sizes or were sporadically reported by a handful of states. In the 2011 NEI, the method described in McCarty et al. 2009 [ref 1] and McCarty 2011 [ref 2] was employed to estimate the emissions from this sector with the exception that states could submit their own estimates. However, this produced significant state to state variability between states that submitted their own data and states that did not. In addition, we received comments that many false detects (EPA emission estimates were too high) occurred using this method (due to dark fields resulting from irrigation) Therefore, a consistent methodology across multiple years for the CONUS has not yet been developed for this sector. With this in mind, for the 2014 NEI, a simple and efficient method has been developed to estimate emissions from crop residue that can easily be applied across multiple years over the CONUS at minimal cost. The method was developed by EPA Office of Research and Development and the reader is directed to a paper in press for details on the methods described below [ref 3].

The approach developed for use in the 2014 NEI improves on previous estimates [ref 1, ref 2] as follows:

- Multiple satellite detections are used to locate fires using an operational product
- Field Size estimates are based on field work studies in multiple states (rather than a one size fits all approach)
- This method allows for intra-annual as well as annual changes in crop land use
- This method incorporates comments on this sector from past NEI efforts to improve the method and remove some of the false detects that occurred in the 2011 NEI
- Additional processing of the HMS data was done to remove 2 types of duplicates
- This method uses USDA NASS Cropland Data Layer (CDL) (USDA, 2015a) [ref 4] information to separate grass/pasture lands, which include Pasture/Grass, Grassland Herbaceous, and Pasture/Hay lands from all other agricultural burning and to identify the crop type
- Removal of agricultural fires from the Hazard Mapping System (HMS) dataset before the application of the SMARTFIRE2 system for wildfires and prescribed fires to eliminate double counting in the NEI and (4) use of state information to further identify fires as crop residue burning rather than another type of fire
- To further identify fires as crop residue burning rather than some kind of wildfire. Our 2014 NEI approach described in this paper complements the method used to estimate emissions from wildfires and prescribed fires because we use crop level land use information to identify crop residue fires and grassland (aka rangeland) fires. The remaining fire detections are used in SMARTFIRE to estimate emissions in forested areas where fuel loadings are available from the National Forest Service.

4.11.3.1 *Activity Data*

The HMS satellite product is an operational satellite product showing hot spots and smoke plumes indicative of fire locations. It is a blended product using algorithms for the Geostationary Operational Environmental Satellite (GOES) Imager, the Polar Operational Environmental Satellite (POES) Advanced Very High Resolution Radiometer (AVHRR), Moderate Resolution Imaging Spectroradiometer (MODIS) and more recently the Visible Infrared

Imaging Radiometer Suite (VIIRS). These satellite detections are provided at 0.001 degrees latitude or longitude but they are derived from active fire satellite products ranging in spatial accuracy from 375 m to 4km. To identify the crop type and to distinguish agricultural fires from all other fires in the HMS product, the USDA Cropland Data Layer (CDL) (USDA, 2015a) [ref 4] was employed. This dataset is produced annually by the USDA National Agricultural Statistics Service and provides high resolution (30 meter) detailed crop information to accurately identify crop types for agricultural fires. According the USDA, the pasture and grass-related land cover categories have traditionally had very low classification accuracy in the CDL (USDA, 2015b) [ref 5]. Moderate spatial and spectral resolution satellite imagery is not ideal for separating grassy land use types, such as urban open space versus pasture for grazing versus CRP grass. To further complicate the matter, the pasture and grass-related categories were not always classified consistently from state to state or year to year (USDA, 2015b). In an effort to eliminate user confusion and category inconsistencies the 1997-2013 CDLs were recoded and re-released in January 2014 to better represent pasture and grass-related categories (USDA, 2015b). A new category named Grass/Pasture (code 176) collapses the following historical CDL categories: Pasture/Grass (code 62), Grassland Herbaceous (code 171), and Pasture/Hay (code 181). This new code (176) has been used to create a single grass/pasture emission source category separate from all other crop types. Based on field reconnaissance of McCarty (2013) [ref 6], a "typical" field size was assumed for each burn location, which varied by region of the country. The assumed field sizes can be found on the file "draft_2014_ag_grasspasture_emissions_nei_may62015.xlsx" on the 2014v1 Supplemental Data FTP site.

4.11.3.2 *Emission Factors*

Emission Factors for CO, NOx, SO_2, $PM_{2.5}$ and PM_{10} were based on Table 1 from McCarty (2011) [ref 3]. The emission factors in McCarty (2011) were based on mean values from all available literature at the time. Emission Factors for NH_3 were derived from the 2002 NEI crop residue emission estimates using the ratio of NH_3/NOx and the NOx emission factor in Table 1 from McCarty (2011). Factor ratios for VOC/CO and the CO emission factors from Table 1 in McCarty (2011) were used to estimate VOC Emission Factors.

Table 4-58 summarizes CAP emission factors, fuel loading, and combustion completeness used in this analysis. For the Hazardous Air Pollutants (HAPs), state-specific HAP augmentation factors were used as they exist in EIS; these factors are constant across all SCCS, and were developed from a previous version of the VOC/HAP inventory for this sector. These HAP augmentation factors are provided in the file "agburning_HAPaug2014NEIv2_table.xlsx" on the 2014v2 Supplemental Data FTP site.

Table 4-58: Emission factors (lbs/ton), fuel loading (tons/acre) and combustion completeness (%) for CAPs

Crop Type	Fuel Loading	Combustion %	CO	NO_x	SO_2	$PM_{2.5}$	PM_{10}	VOC	NH_3
corn	4.20 [a]	75 [a]	106.10[a]	4.60 [a]	2.38 [a]	9.94 [a]	21.36 [a]	6.60 [c]	19.32 [b]
wheat	1.90 [a]	85 [a]	110.28 [a]	4.75 [a]	0.88 [a]	8.07 [a]	14.10 [a]	7.60 [c]	33.73 [b]
soybean	2.50 [a]	75 [a]	127.70 [a]	6.33 [a]	3.13 [a]	12.38 [a]	17.73 [a]	11.97 [c]	44.94 [b]
cotton	2.18 [a]	65 [a]	146.12 [a]	6.89 [a]	3.13 [a]	12.38 [a]	17.73 [a]	11.97 [c]	48.92 [b]
fallow	2.18 [a]	75 [a]	127.79 [a]	5.60 [a]	2.34 [a]	12.31 [a]	17.00 [a]	11.97 [c]	16.24 [b]
rice	3.00 [a]	75 [a]	105.27 [a]	6.23 [a]	2.77 [a]	4.72 [a]	6.61 [a]	5.00 [c]	26.17 [b]
sugarcane	4.75 [a]	65 [a]	116.95 [a]	6.06 [a]	3.32 [a]	8.69 [a]	9.83 [a]	9.00 [c]	43.03 [b]
lentils	2.94 [a]	75 [a]	127.79 [a]	5.60 [a]	2.34 [a]	12.31 [a]	17.00 [a]	11.97 [c]	39.76 [b]
Other crops	1.90 [a]	85 [a]	182.11 [a]	4.31 [a]	0.80 [a]	23.23 [a]	31.64 [a]	10.70 [c]	12.52 [b]
Dbl. Crop	3.05 [d]	80 [d]	108.19 [d]	4.68 [d]	1.63 [d]	9.00 [d]	17.73 [d]	7.10 [d]	26.53 [d]
Dbl. Crop	3.19 [d]	75 [d]	116.95 [d]	5.10 [d]	2.36 [d]	11.13 [d]	19.18 [d]	8.45 [d]	21.41 [d]

Crop Type	Fuel Loading	Combustion %	CO	NO_x	SO_2	$PM_{2.5}$	PM_{10}	VOC	NH_3
Dbl. Crop	2.18 [d]	75 [d]	127.79 [d]	5.60 [d]	2.34 [d]	12.31 [d]	17.00 [d]	11.97 [d]	39.74 [d]
Dbl. Crop	2.04 [d]	80 [d]	119.04 [d]	5.17 [d]	1.61 [d]	10.19 [d]	15.55 [d]	6.35 [d]	36.74 [d]
Dbl. Crop	2.04 [d]	80 [d]	119.04 [d]	5.17 [d]	1.61 [d]	10.19 [d]	15.55 [d]	6.35 [d]	36.74 [d]
Dbl. Crop	3.05 [d]	80 [d]	108.19 [d]	4.68 [d]	1.63 [d]	9.00 [d]	17.73 [d]	10.80 [d]	19.63 [d]
Dbl. Crop	2.04 [d]	75 [d]	128.20 [d]	5.82 [d]	2.01 [d]	10.22 [d]	15.91 [d]	11.97 [d]	41.33 [d]
Dbl. Crop	2.34 [d]	7 [d]	136.91 [d]	6.61 [d]	3.13 [d]	12.38 [d]	17.73 [d]	11.97 [d]	46.94 [d]
Dbl. Crop	2.34 [d]	75 [d]	127.75 [d]	5.96 [d]	2.74 [d]	12.35 [d]	17.36 [d]	11.97 [d]	42.35 [d]
Dbl. Crop	3.35 [d]	75 [d]	116.90 [d]	5.46 [d]	2.76 [d]	11.16 [d]	19.55 [d]	11.97 [d]	22.94 [d]
Dbl. Crop	2.2 [d]	80 [d]	118.99 [d]	5.54 [d]	2.01 [d]	10.22 [d]	15.91 [d]	9.79 [d]	39.33 [d]
Dbl. Crop	2.04 [d]	80 [d]	119.04 [d]	5.17 [d]	1.61 [d]	10.19 [d]	15.55 [d]	9.79 [d]	36.74 [d]
Pasture_Gra	1.9 [a]	85 [a]	182.11 [a]	4.31 [a]	0.80 [a]	23.23 [a]	31.64 [a]	10.70 [c]	12.52 [b]

[a]: McCarty (2011) [ref 2], Fuel Loading and Combustion completeness from Data and Methods Section Table 1 converted to lbs/ton for factors

[b] 2002 NEI NH_3/NO_X ratio

[c] VOC AP42 factors ratio to CO factors from McCarty 2011.

[d] average of two field crops

4.11.3.3 *Computing EPA estimates*

The general procedure for generating final 2014 NEI v1 EPA estimates is outlined here. The reader is referred to Pouliot et al., 2016 [ref 3] for further details. The HMS satellite detections were processed through 5 layers of filtering to find crop residue and rangeland burning.

- The first layer of filtering removed all detections outside the lower 48 states.
- The second layer of filtering removed the detections that were identified as wildland and prescribed fires because they occurred in a non-agricultural region. This identification was made by intersecting the USDA Crop Data Layers (CDL) with the remaining HMS detects to determine a crop type. Given that the satellite detections are at best known to 100 meters and the CDL information is known to 30-meter resolution, the process of intersecting these two datasets results in some uncertainty with respect to spatial accuracy of the fire locations.
- The third layer of filtering involved the use of snow cover estimates. Using the daily maximum snow cover data from a Weather Research and Forecasting Model (WRF) model simulation for 2014, HMS satellite detections from GOES, MODIS, and AVHRR that were coincident with snow cover were deemed not to be crop residue burning but some other type of fire.
- The fourth layer of filtering was based on comments (from the draft 2014 NEI estimates posted in June 2015) from specific states regarding specific crops.
    - Corn and soybean detections for these eight Midwestern states (Iowa, Indiana, Illinois, Michigan, Missouri, Minnesota, Wisconsin, and Ohio) were deemed to be a different type of fire other than crop residue burning. The reasoning is based on a communication from Iowa State University Extension and Outreach: "Burning corn and soybean fields is just NOT a practice that is used in Iowa or many other Midwest States as a way of preparing the fields for planting a subsequent crop. Yes, there are rare occasions where corn residue is burnt off a field but it would not even be1% of the crop acres. An example would be if the residue washed and piled up in an area it may be burnt to allow tillage, planting and other practices to occur. Another rare

occasion is when accidental field fires occur during harvesting of the corn crop. But again, this would be less than 1% of the crop acres."

  - Communication from the state of Indiana was similar to that of Iowa with respect to corn and soybeans.
  - The other six Midwestern states (Illinois, Michigan, Missouri, Minnesota, Wisconsin, and Ohio) were included because of their proximity to the Indiana and Iowa so that the method would consistent at a regional scale. These fires that are not being identified as crop residue burning or rangeland burning are being classified as accidental rather than intentional burning.
  - Also as part of the 4th layer of filtering, if localized state information identified a fire as being accidental but in the vicinity of agricultural land, we deemed these fires not to be crop residue burning but in the wildfire category. This was the case for the state of Delaware.
- The fifth level of filtering was the process of removing duplicates. The remaining HMS satellite detections were checked for two types of duplicates. If a GOES satellite detection was within 2 km and within an hour of another detection, the detection was deemed to be a duplicate and removed. Identical latitude and longitude detections to 3 decimal places on the same day across all satellites were also deemed to be duplicates and they were removed. For the first type of duplicate, approximately 1% of the total detections

Then, using the CA emission factors in Table 4-58, and the assumed state-specific field size, daily emissions were estimated for each fire detection. Emissions for the grass/pasture category were mapped to a single source classification code (SCC 2801500170) for use in the NEI. Emissions for all the remaining CDL categories were mapped to a set of source classification codes. Theses codes and the mapping is available 2014 NEI Documentation web site. HAPs were estimated using state-specific HAP augmentation factors (fractions that are multiplied by VOC emissions to get HAPs) found in EIS for this sector.

Emission Estimates for 2014

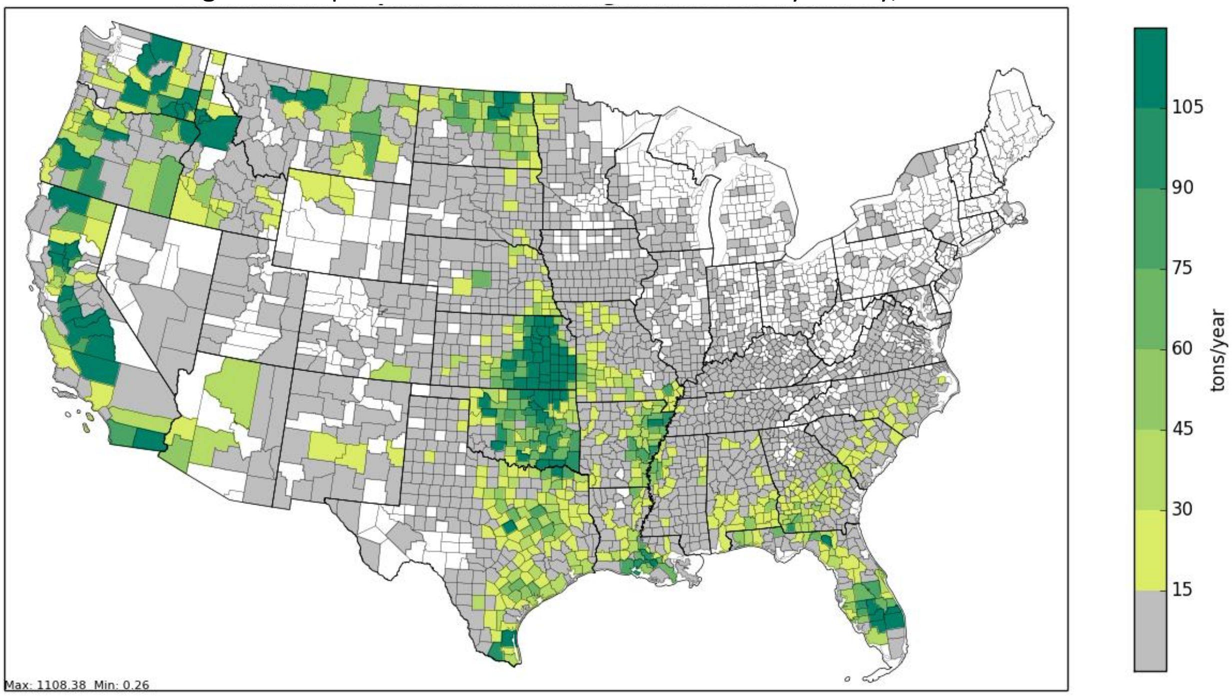
Table 4-59 summarizes state level estimates of crop residue burning by acres burned and $PM_{2.5}$ for 2014 using the EPA methods described above. The top two states for crop residue burning ($PM_{2.5}$ and acres) were California and Kansas. The top two states for grass/pasture burns were Kansas and Oklahoma. For Grasslands, we would expect these two states to have the largest acres burned because of the annual prescribed burning of the Flint Hills Grasslands and the large geographical extent of these regions. The grass/pasture burns are also known as rangeland burning, based on the definition of the grass/pasture land use in the Cropland Data Layer. Figure 4-8 provides a spatial map of the annual emissions by county for 2014 using this method for crop residue and rangeland burning. We note that crop residue and rangeland burning is not widespread but occurs in a few specific regions of the country.

Table 4-59: Acres burned and $PM_{2.5}$ emissions by state using EPA methods

State	2014 Crop Acres	2014 Crop $PM_{2.5}$ (tons/yr)	2014 Grass/Pasture Acres	2014 Grass/Pasture $PM_{2.5}$ (tons/yr)
Alabama	21,000	307	32,240	605
Arizona	8,240	118	2,800	53
Arkansas	137,160	1,371	28,400	533
California	202,560	2,854	51,240	961
Colorado	4,240	63	3,840	72
Florida	147,540	2,142	79,440	1,490
Georgia	100,240	1,351	39,360	738

State	2014 Crop Acres	2014 Crop $PM_{2.5}$ (tons/yr)	2014 Grass/Pasture Acres	2014 Grass/Pasture $PM_{2.5}$ (tons/yr)
Idaho	50,880	650	35,400	664
Illinois	1,680	18	7,980	150
Indiana	660	7	3,480	65
Iowa	3,660	69	14,940	280
Kansas	180,720	2,207	461,600	8,655
Kentucky	8,000	110	7,760	146
Louisiana	87,920	1,052	20,000	375
Maryland	800	10	160	3
Massachusetts	80	2	40	1
Michigan	640	11	480	9
Minnesota	17,280	220	4,200	79
Mississippi	45,600	537	21,200	398
Missouri	31,980	327	71,880	1,348
Montana	32,760	428	32,640	612
Nebraska	29,820	419	25,200	473
Nevada	360	5	520	10
New Jersey	160	3	120	2
New Mexico	1,120	17	7,120	134
New York	600	10	320	6
North Carolina	32,000	406	8,200	154
North Dakota	117,480	1,402	29,700	557
Ohio	400	5	1,320	25
Oklahoma	49,440	506	299,600	5,618
Oregon	29,400	433	54,240	1,017
Pennsylvania	360	6	440	8
South Carolina	16,080	197	12,480	234
South Dakota	18,660	270	8,160	153
Tennessee	8,400	102	10,440	196
Texas	74,480	961	184,000	3,450
Utah	1,520	23	880	17
Vermont	40	1	0	0
Virginia	3,760	56	4,280	80
Washington	70,920	883	43,200	810
West Virginia	200	3	520	10
Wisconsin	720	13	2,640	50
Wyoming	2,720	48	2,240	42
TOTAL	1,542,280	19,623	1,614,700	30,276

Figure 4-8: Spatial distribution of $PM_{2.5}$ emissions by county, EPA method



4.11.3.4 *Quality assurance of final estimates*

Some of the QA was done as part of the new methods used for this sector, and described above. Further review of the quality of EPA's data included addressing of S/L/T comments as outlined in earlier sections of this section. In addition, the following checks were done on EPA data:

- Comparison to past NEI estimates, and explaining differences noted
- Check of diurnal profile using day specific data generated by EPA methods with existing profiles used for air quality modeling
- Using past comments received from S/L/Ts for this sector to ground truth estimates

The QA of S/L/T-submitted data included checking with EPA estimates, working with S/L/Ts to understand why differences exist, and making sure pollutant coverage is complete.

It is not expected that we will make any major changes/improvements to this sector (methods, pollutants reported, etc.) in going from v1 to v2. We will address those comments we do receive to the best of our ability and with resources that we have.

4.11.4 References for agricultural field burning

1. McCarty, J.L., S. Korontzi, C. O. Justice, and T. Loboda. 2009. *The spatial and temporal distribution of crop residue burning in the contiguous United States*. Science of the Total Environment 407 (21), 5701-5712.
2. McCarty, J. L. 2011. *Remote Sensing-Based Estimates of Annual and Seasonal Emissions from Crop Residue Burning in the Contiguous United States*. Journal of the Air & Waste Management Association 61 (1), 22-34.
3. Pouliot, G., Rao, V., McCarty, J. L., and A. Soja. 2017. *Development of the crop residue and rangeland burning in the 2014 National Emissions Inventory using information from multiple sources*. Journal of the Air & Waste Management Association Vol. 67, Issue 5.

4. United States Department of Agriculture. 2015a. USDA National Agricultural Statistics Service Cropland Data Layer *for 2015.*
5. United States Department of Agriculture. 2015b. USDA National Agricultural Statistics Service Cropland Data Layer Frequently Asked Questions, accessed April 1, 2015
6. Personal communication with Dr J. McCarty, 2013, Michigan Technological Institute.

4.12 Fuel Combustion -Industrial and Commercial/Institutional Boilers and ICEs

Emissions from Industrial, Commercial, and Institutional (ICI) fuel combustion are a significant portion of the total emissions inventory for many areas. Unless all ICI combustion emission sources are provided in an S/L/T point inventory submittal, it is necessary for inventory preparers to estimate ICI combustion nonpoint source emissions. Because there are specific challenges associated with estimating ICI nonpoint source emissions, the EPA developed a Microsoft® Access-based ICI Combustion Tool to assist S/L/Ts in estimating nonpoint emissions from ICI fuel combustion for the 2014 National Emission Inventory. We discuss the ICI tool in Section 4.12.3.

4.12.1 Sector description

The EIS sectors to be documented here include nonpoint emissions from ICI fuel combustion:

- Fuel Combustion – Commercial/Institutional Boilers, ICEs – Biomass
- Fuel Combustion – Commercial/Institutional Boilers, ICEs – Coal
- Fuel Combustion – Commercial/Institutional Boilers, ICEs – Natural Gas
- Fuel Combustion – Commercial/Institutional Boilers, ICEs – Oil
- Fuel Combustion – Commercial/Institutional Boilers, ICEs – Other
- Fuel Combustion – Industrial Boilers, ICEs – Biomass
- Fuel Combustion – Industrial Boilers, ICEs – Coal
- Fuel Combustion – Industrial Boilers, ICEs– Natural Gas
- Fuel Combustion – Industrial Boilers, ICEs – Oil
- Fuel Combustion – Industrial Boilers, ICEs – Other

We document all these sectors in this section because EPA generates all the nonpoint emissions from these EIS sectors via an ICI Tool. S/L/Ts were encouraged to use this tool to generate and submit all their nonpoint ICI emissions.

4.12.2 Sources of data

Table 4-60 shows, for ICI fuel combustion, the nonpoint SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 2, 3 and 4 SCC descriptions are also provided except for the last SCC (2801520000), where the full SCC description is provided. The SCC level 1 description is "Stationary Source Fuel Combustion" for all SCCs except the last one (2801520000). The leading sector description is "Fuel Comb"(ustion) for all SCCs.

Table 4-60: ICI fuel combustion SCCs with 2014 NEI emissions

Sector type	SCC	Description	EPA	State	Local	Tribe
Comm/Institutional - Biomass	2103008000	Commercial/Institutional; Wood; Total: All Boiler Types	X	X	X	X
Comm/Institutional - Coal	2103001000	Commercial/Institutional; Anthracite Coal; Total: All Boiler Types	X	X	X	X

Sector type	SCC	Description	EPA	State	Local	Tribe
Comm/Institutional - Coal	2103002000	Commercial/Institutional; Bituminous/Subbituminous Coal; Total: All Boiler Types	X	X	X	
Comm/Institutional - Natural Gas	2103006000	Commercial/Institutional; Natural Gas; Total: Boilers and IC Engines	X	X	X	
Comm/Institutional - Oil	2103004000	Commercial/Institutional; Distillate Oil; Total: Boilers and IC Engines		X		X
Comm/Institutional - Oil	2103004001	Commercial/Institutional; Distillate Oil; Boilers	X	X	X	
Comm/Institutional - Oil	2103004002	Commercial/Institutional; Distillate Oil; IC Engines	X	X	X	
Comm/Institutional - Oil	2103005000	Commercial/Institutional; Residual Oil; Total: All Boiler Types	X	X	X	
Comm/Institutional - Oil	2103011000	Commercial/Institutional; Kerosene; Total: All Combustor Types	X	X	X	
Comm/Institutional - Other	2103007000	Commercial/Institutional; Liquified Petroleum Gas (LPG); Total: All Combustor Types	X	X	X	
Industrial Boilers, ICEs - Biomass	2102008000	Industrial; Wood; Total: All Boiler Types	X	X	X	X
Industrial Boilers, ICEs - Coal	2102001000	Industrial; Anthracite Coal; Total: All Boiler Types	X	X	X	
Industrial Boilers, ICEs - Coal	2102002000	Industrial; Bituminous/Subbituminous Coal; Total: All Boiler Types	X	X	X	
Industrial Boilers, ICEs - Natural Gas	2102006000	Industrial; Natural Gas; Total: Boilers and IC Engines	X	X	X	
Industrial Boilers, ICEs - Oil	2102004000	Industrial; Distillate Oil; Total: Boilers and IC Engines		X		
Industrial Boilers, ICEs - Oil	2102004001	Industrial; Distillate Oil; All Boiler Types	X	X	X	X
Industrial Boilers, ICEs - Oil	2102004002	Industrial; Distillate Oil; All IC Engine Types	X	X	X	X
Industrial Boilers, ICEs - Oil	2102005000	Industrial; Residual Oil; Total: All Boiler Types	X	X	X	
Industrial Boilers, ICEs - Oil	2102011000	Industrial; Kerosene; Total: All Boiler Types	X	X	X	X
Industrial Boilers, ICEs - Other	2102007000	Industrial; Liquified Petroleum Gas (LPG); Total: All Boiler Types	X	X	X	X
Industrial Boilers, ICEs - Other	2102012000	Industrial; Waste oil; Total		X		
Industrial Boilers, ICEs - Other	2801520000	Miscellaneous Area Sources; Agriculture Production - Crops; Orchard Heaters; Total, all fuels		X		

The agencies listed in Table 4-61 submitted nonpoint inventory NO_X emissions for these sectors; agencies not listed used EPA estimates for all ICI sectors. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%). Table 4-62 provides the same agency submittal information for SO_2 and Table 4-63 provides the same information for (primary) $PM_{2.5}$ agency submittals.

Table 4-61: Percentage of ICI fuel combustion NO_X emissions submitted by reporting agency

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
1	Connecticut Department of Energy and Environmental Protection	100		100	100	100	100		100	100	100
1	Maine Department of Environmental Protection	100		100	100	100			100	100	
1	Massachusetts Department of Environmental Protection	100		100	100	100	100		100	100	100
1	New Hampshire Department of Environmental Services	100		100	100	100			100	100	100
1	Rhode Island Department of Environmental Management	100		100	100	100	100		100	100	100
1	Vermont Department of Environmental Conservation	100		100	100	100			100	100	100
2	New Jersey Department of Environment Protection			100	100	100				100	100
2	New York State Department of Environmental Conservation	100		100	100	100	100	100		100	100
2	Puerto Rico				100	100				100	100
3	DC-District Department of the Environment	100		100	100	100				100	100
3	Delaware Department of Natural Resources and Environmental Control			100	100	100			100	100	
3	Maryland Department of the Environment		100	100	100	100					
3	Pennsylvania Department of Environmental Protection	100	100	100	100	100	100	100	100	100	100
3	Virginia Department of Environmental Quality	100	100	100	100	100	100		100	100	
3	West Virginia Division of Air Quality	100		100	100	100		100		100	
4	Chattanooga Air Pollution Control Bureau (CHCAPCB)			100	100	100			100	100	100
4	Florida Department of Environmental Protection	100		100	100	100	100			100	

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
4	Georgia Department of Natural Resources			100	100	100			100	12	
4	Knox County Department of Air Quality Management			100	100	100			100	100	100
4	Louisville Metro Air Pollution Control District	100		100	100	100	100			100	100
4	Memphis and Shelby County Health Department - Pollution Control	100		100	100	100			100	100	100
4	Metro Public Health of Nashville/Davidson County			100							
4	North Carolina Department of Environment and Natural Resources	100	100	100	100	100	100		100	100	
4	South Carolina Department of Health and Environmental Control	100		100	100	100	100		100	100	
4	Tennessee Department of Environmental Conservation		100	100	100	100	100	100		100	100
5	Illinois Environmental Protection Agency			100	100	100			100	100	
5	Indiana Department of Environmental Management	100		100	100	100	100			100	100
5	Michigan Department of Environmental Quality		100	100	48	100	100	100	100	31	100
5	Minnesota Pollution Control Agency	100		100	100	100	100	100	100	100	100
5	Ohio Environmental Protection Agency	100	100	100	100	100	100		100	100	100
5	Wisconsin Department of Natural Resources	100		100	100	100	100		100	100	100
6	Arkansas Department of Environmental Quality	100		100	100	100	100			100	100
6	City of Albuquerque	100		100	100	100	100	100	100	100	100
6	Louisiana Department of Environmental Quality	100			100	100	100	100		100	100
6	Oklahoma Department of Environmental Quality	100		100	100	100	100			100	100
6	Texas Commission on Environmental Quality			100	100	100			100	100	100
7	Iowa Department of Natural Resources	100		100	100	100	100			100	100
7	Kansas Department of Health and Environment	100		100	100	100		100		100	100

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
7	Missouri Department of Natural Resources	100		100	100	100			100	100	100
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation			100							
8	Northern Cheyenne Tribe	100	100		100	100					
8	Utah Division of Air Quality	100		100	100	100	100		100	100	100
9	Arizona Department of Environmental Quality	100		100	100	100	100	100	100	100	100
9	California Air Resources Board			96	100	59			81	100	77
9	Clark County Department of Air Quality and Environmental Management			100	100	100		100		100	100
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California				100						
9	Washoe County Health District			100	100	100			100	100	100
10	Alaska Department of Environmental Conservation			7	100				100	94	
10	Coeur d'Alene Tribe	100	100	100	100	100	100		100	100	100
10	Idaho Department of Environmental Quality	100	100	100	100	100	100		100	100	100
10	Kootenai Tribe of Idaho	100	100	100	100	100			100	100	100
10	Nez Perce Tribe	100	100	100	100	100	100		100	100	100
10	Oregon Department of Environmental Quality	100		100	100	100		100	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	100	100	100	100	100	100		100	100	100
10	Washington State Department of Ecology	100		100	100	100	100	100	100	100	100

Table 4-62: Percentage of ICI fuel combustion SO_2 emissions submitted by reporting agency

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
1	Connecticut Department of Energy and Environmental Protection	100		100	100	100	100		100	100	100

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
1	Maine Department of Environmental Protection	100		100	100	100			100	100	
1	Massachusetts Department of Environmental Protection	100		100	100	100	100		100	100	100
1	New Hampshire Department of Environmental Services	100		100	100	100			100	100	100
1	Rhode Island Department of Environmental Management	100		100	100	100	100		100	100	100
1	Vermont Department of Environmental Conservation	100		100	100	100			100	100	100
2	New Jersey Department of Environment Protection			100	100	100				100	100
2	New York State Department of Environmental Conservation	100		100	100	100	100	100		100	100
2	Puerto Rico				100					100	
3	DC-District Department of the Environment	100		100	100	100				100	100
3	Delaware Department of Natural Resources and Environmental Control			100	100	100			100	100	
3	Maryland Department of the Environment		100	100	100	100					
3	Pennsylvania Department of Environmental Protection	100	100	100	100	100	100	100	100	100	100
3	Virginia Department of Environmental Quality	100	100	100	100	100	100		100	100	
3	West Virginia Division of Air Quality	100		100	100	100		100		100	
4	Chattanooga Air Pollution Control Bureau (CHCAPCB)			100	100	100			100	100	100
4	Florida Department of Environmental Protection	100		100	100	100		100		100	
4	Georgia Department of Natural Resources			100	100	100				88	
4	Knox County Department of Air Quality Management			100	100	100			100	100	100
4	Louisville Metro Air Pollution Control District	100		100	100	100	100			100	100
4	Memphis and Shelby County Health Department - Pollution Control	100		100	100	100			100	100	100

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
4	Metro Public Health of Nashville/Davidson County			100							
4	North Carolina Department of Environment and Natural Resources	100	100	100	100	100	100		100	100	
4	South Carolina Department of Health and Environmental Control	100		100	100	100	100		100	100	
4	Tennessee Department of Environmental Conservation			100	100	100				100	100
5	Illinois Environmental Protection Agency			100	100	100			100	100	
5	Indiana Department of Environmental Management	100		100	100	100	100			100	100
5	Michigan Department of Environmental Quality		100	100	39	100	100	100	100	69	100
5	Minnesota Pollution Control Agency	100		100	100	100	100	100	100	100	100
5	Ohio Environmental Protection Agency	100	100	100	100	100	100		100	100	100
5	Wisconsin Department of Natural Resources	100		100	100	100	100		100	100	100
6	Arkansas Department of Environmental Quality	100		100	100	100				100	100
6	City of Albuquerque	100			100	100	100	100	100	100	100
6	Louisiana Department of Environmental Quality	100			100	100	100	100		100	100
6	Oklahoma Department of Environmental Quality	100		100	100	100	100			100	100
6	Texas Commission on Environmental Quality			100	100	100			100	100	100
7	Iowa Department of Natural Resources	100		100	100	100	100		100	100	100
7	Kansas Department of Health and Environment	100		100	100	100		100		100	100
7	Missouri Department of Natural Resources	100		100	100	100			100	100	100
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation			100							
8	Northern Cheyenne Tribe	100	100		100	100					
8	Utah Division of Air Quality	100		100	60	100	100		100	100	100
9	Arizona Department of Environmental Quality	100		100	100	100	100	100	100	100	100
9	California Air Resources Board			100	100	100			100	100	100

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
9	Clark County Department of Air Quality and Environmental Management				100	100		100		100	
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California				100						
9	Washoe County Health District			100	100	100			100	100	100
10	Alaska Department of Environmental Conservation			100	92					75	
10	Coeur d'Alene Tribe	100	100	100	100	100	100		100	100	100
10	Idaho Department of Environmental Quality	100	100	100	100	100	100		100	100	100
10	Kootenai Tribe of Idaho	100	100	100	100	100			100	100	100
10	Nez Perce Tribe	100	100	100	100	100	100		100	100	100
10	Oregon Department of Environmental Quality	100		100	100	100		100	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	100	100	100	100	100	100		100	100	100
10	Washington State Department of Ecology	100		100	100	100	100	100	100	100	100

Table 4-63: Percentage of ICI fuel combustion $PM_{2.5}$ emissions submitted by reporting agency

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
1	Connecticut Department of Energy and Environmental Protection	100		100	100	100	100		100	100	100
1	Maine Department of Environmental Protection	100		100	100	100			100	100	
1	Massachusetts Department of Environmental Protection	100		100	1	100	100		100	0	100
1	New Hampshire Department of Environmental Services	100		100	100	97			100	100	100
1	Rhode Island Department of Environmental Management	100		100	100	100	100			100	100

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
1	Vermont Department of Environmental Conservation	100		100	100	100			100	100	100
2	New Jersey Department of Environment Protection			100	100	100				100	100
2	New York State Department of Environmental Conservation	100		100	100	100	100	100		100	100
2	Puerto Rico				2					66	
3	DC-District Department of the Environment	100		100	100	100				100	100
3	Delaware Department of Natural Resources and Environmental Control			100	67	100			100	100	
3	Maryland Department of the Environment			100	100	100					
3	Pennsylvania Department of Environmental Protection	100	100	100	100	100	100	100	100	100	100
3	Virginia Department of Environmental Quality	100	100	100	100	100	100		100	100	
3	West Virginia Division of Air Quality	100		100	100	100		100		100	
4	Chattanooga Air Pollution Control Bureau (CHCAPCB)				100	100				100	100
4	Florida Department of Environmental Protection	100			100	100	100	100		100	
4	Georgia Department of Natural Resources			100	100	100				2	
4	Knox County Department of Air Quality Management			100	100	100			100	100	100
4	Louisville Metro Air Pollution Control District	100		100	100	100	100			100	100
4	Memphis and Shelby County Health Department - Pollution Control	100		100	2	100			100	100	100
4	North Carolina Department of Environment and Natural Resources	100	100	100	100	100	100		100	100	
4	South Carolina Department of Health and Environmental Control	100		100	100	100	100		100	100	
4	Tennessee Department of Environmental Conservation	100	100		100	100	91	99		98	100

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
5	Illinois Environmental Protection Agency			100	100	100			100	100	
5	Indiana Department of Environmental Management	100		100	100	100	100			100	100
5	Michigan Department of Environmental Quality						100				100
5	Minnesota Pollution Control Agency	100		100	100	100	100	100	100	100	100
5	Ohio Environmental Protection Agency	100	100	100	100	100	100		100	100	100
5	Wisconsin Department of Natural Resources	100		100	100	100	100		100	100	100
6	City of Albuquerque	100			100	100	100	100		96	100
6	Louisiana Department of Environmental Quality	100			100	100	100	100		100	100
6	Oklahoma Department of Environmental Quality	100		100	100	100	100			100	100
6	Texas Commission on Environmental Quality			100	99	100			100	63	100
7	Iowa Department of Natural Resources	100			100	100	100			100	100
7	Kansas Department of Health and Environment	100			100	100	100	100		100	100
7	Missouri Department of Natural Resources	100		100	100	100			100	100	100
8	Northern Cheyenne Tribe	100									
8	Utah Division of Air Quality	100		100	100	100	100		100	100	100
9	Arizona Department of Environmental Quality	100		100	100	100	100	100	100	100	100
9	California Air Resources Board			100	100	98			100	100	100
9	Clark County Department of Air Quality and Environmental Management				100	100		100			100
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California				100						
9	Washoe County Health District									100	

Region	Agency	Comm/Inst Biomass	Comm/Inst Coal	Comm/Inst Nat Gas	Comm/Inst Oil	Comm/Inst Other	Ind Biomass	Ind Coal	Ind Nat Gas	Ind Oil	Ind Other
10	Coeur d'Alene Tribe	100	100	100	100	100	100		100	100	100
10	Idaho Department of Environmental Quality	100	100	100	100	100	100		100	100	100
10	Kootenai Tribe of Idaho	100	100	100	100	100			100	100	100
10	Nez Perce Tribe	100	100	100	100	100	100		100	100	100
10	Oregon Department of Environmental Quality	100		100	100	100		100	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	100	100	100	100	100	100		100	100	100
10	Washington State Department of Ecology	100		100	100	100	100	100	100	100	100

4.12.3 EPA-developed emissions for ICI fuel combustion

The primary data source behind the ICI Combustion Tool is total state-level ICI energy consumption data released annually as part of the Energy Information Administration's State Energy Data System (SEDS) [ref 1]. The ICI Combustion Tool processes the SEDS data and adjusts the data to account for the fraction of fuel consumed by nonroad mobile sources whose emissions are included in the nonroad inventory and by non-fuel combustion uses of energy, such as product feedstocks. Through a user-friendly interface, users can update the underlying assumptions in the adjustment methodology. The ICI Combustion Tool also includes a nonpoint source to point source crosswalk and allows the user to perform point source activity subtractions to avoid double counting of emissions between their point and nonpoint inventories. The ICI Combustion Tool generates outputs in EPA's Emissions Inventory System (EIS) format, ready for submission to the EIS. Complete ICI Combustion Tool documentation and a User's Guide are available in the file "ICI v1.6.zip" on the 2014v2 Supplemental Data FTP site.

ICI combustion nonpoint source emissions are calculated using Equation 1.

$$E_{s,f} = A_{s,f} * F_{s,f} \qquad (1)$$

where:

E = computed emissions,
A = emissions activity,
F = emissions factor,
s = sector (Industrial or Commercial/Institutional),
f = fuel type (coal, natural gas, distillate oil, residual oil, liquefied petroleum gas, kerosene and wood).

The key emissions activity data inputs in the emissions estimation methodology are:

1. Total Industrial and total Commercial/Institutional energy consumption by fuel type and state for a given year;
2. Industrial energy consumed for non-fuel purposes by fuel type and state in that year;
3. ICI distillate oil and liquefied petroleum gas (LPG) consumption by state from nonroad mobile sources for the year of interest;
4. ICI energy consumption by sector, state, and fuel type for point sources for the given year; and
5. County-level employment by ICI sector and state for the year of interest.

The ICI Tool also relies on emission factors relating emission rates to the volume of fuel burned by sector/fuel type, and the sulfur content of coal consumed in each sector by state for the given year.

ICI combustion emissions are directly related to the sector, type, and volume of fuel burned. The EIA is responsible for developing official federal government estimates of energy consumption. The EIA estimates annual energy consumption at the state-level as part of the State Energy Data System (SEDS) [ref 1]. The SEDS reports energy consumption estimates by state, sector, fuel type, and year. The SEDS provides data for each of five consuming sectors, including Industrial and Commercial (note that the SEDS' definition of "Commercial" includes Institutional sector use). The EIA also publishes additional detailed estimates of state-level fuel oil and kerosene consumption estimates in their *Fuel Oil and Kerosene Sales* publication [ref 2]. This publication provides state-level annual end use sales of No.1, No. 2, and No. 4 distillate fuel oil for commercial, industrial, oil company, farm, off-highway construction, and other uses – these data are used to differentiate stationary from mobile source distillate fuel consumption.

4.12.3.1 *Activity data adjustments*

Fuel-specific adjustments

Coal – For coal combustion, it is necessary to compile data representing a subset of total sector coal consumption. Data representing non-coke plant consumption are compiled from EIA because coal consumed by coke plants is accounted for in the point source inventory. The SEDS data do not provide coal consumption estimates by type of coal (i.e., anthracite versus bituminous/subbituminous). Therefore, state-level ICI coal distribution data for 2013 from the EIA's *Annual Coal Distribution Report 2013* are used to allocate coal consumption between the two types of coal [ref 3]. The 2013 ratio of anthracite coal consumption to total coal consumption is used for this allocation procedure.

Distillate Oil and LPG – The SEDS ICI distillate oil and LPG consumption data include consumption estimates for equipment that are typically included in the nonroad sector inventory. In particular, SEDS considers the following nonroad source category activities to be part of the industrial sector: farming, logging, mining, and construction.

In order to avoid double-counting of distillate oil consumption between the nonpoint and nonroad sector emission inventories, the more detailed distillate oil consumption estimates reported in EIA's *Fuel Oil and Kerosene Sales* are combined with assumptions used in the regulatory impact analysis (RIA) for EPA's nonroad diesel emissions rulemaking [ref 3, ref 4].

For distillate fuel, Table 4-64 presents the assumptions that are applied to the state-level Commercial sector distillate oil consumption data published in *Fuel Oil and Kerosene Sales* to estimate Commercial sector stationary source consumption.

Table 4-64: Stationary source adjustments for industrial sector distillate fuel consumption

EIA Energy Sector	Distillate Fuel Type	% of Total Consumption from Stationary Sources
Industrial	No. 1 Distillate Fuel Oil	60
	No. 2 Distillate Fuel Oil	100
	No. 2 Distillate/Low and High Sulfur Diesel	15[a]
	No. 4 Distillate Fuel Oil	100
Farm	Diesel	0
	Other Distillate Fuel Oil	100
Off-Highway (Construction and Other)	Distillate Fuel Oil	5
Oil Company	Distillate Fuel Oil	50

[a] This value differs from the 0% assumption adopted in EPA's nonroad diesel emissions rulemaking because it is known that some diesel fuel is used by stationary sources (a 15 percent value was selected for use as an approximate mid-point of a potential range of 8% to 24% stationary source use computed from a review of data from the EIA's *Manufacturing Energy Consumption Survey* and *Fuel Oil and Kerosene Sales*).

Table 4-65 presents the assumptions that are applied to the state-level Commercial sector distillate oil consumption data published in Fuel Oil and Kerosene Sales to estimate Commercial sector stationary source consumption.

Table 4-65: Stationary source adjustments for commercial sector distillate fuel consumption

EIA Energy Sector	Distillate Fuel Type	% of Total Consumption from Stationary Sources
Commercial	No. 1 Distillate Fuel Oil	80
	No. 2 Distillate Fuel Oil	100
	No. 2 Distillate/Ultra-Low, Low, and High Sulfur Diesel	0[a]
	No. 4 Distillate Fuel Oil	100

[a] A very small portion of total commercial/institutional diesel is consumed by point sources (SCC 203001xx).

To avoid double-counting of LPG consumption, the ICI Tool uses data from the EPA National Mobile Inventory Model (NMIM) for 2006 to calculate the national volume of nonroad LPG consumption from agriculture, logging, mining, and construction source categories. This estimate is then divided into the SEDS total LPG consumption estimate to yield the proportion of total ICI LPG consumption attributable to the nonroad sector in that year (8.72% for industrial sources and 17.72% for commercial/institutional sources). It is assumed that these proportions are appropriate for future inventory years. This estimate of the nonroad portion of LPG consumption is subtracted from each state's ICI LPG consumption estimate reported in SEDS.

Distillate oil is reported by EIA as the total consumption of distillate. Therefore, as shown in Table 4-66, assumptions must be made to determine the amount of distillate consumed by boilers and internal combustion engines; these values are an update in the 2014v2 NEI. The default assumptions were calculated using data from the EIA, but S/L/T agencies are encouraged to update the default assumptions with better state-level data, if available.

The default boiler/engine split assumptions for industrial distillate consumption were calculated using data from EIA's *2010 Manufacturing Energy Consumption Survey (MECS)*, Table 5.5 [ref 6], which provides data on distillate consumption by end use for the industrial sector. The boiler/engine split was calculated at the national level, because data was withheld for too many end uses at the regional level. The following end uses from MECS are assumed to be associated with engines: electricity generation (which assumes the electricity is generated using internal combustion engine generators) and machine drive (which includes use by motors, pumps, etc.). All other end uses are assumed to be associated with boilers. The total national-level distillate consumption for engine-based and boiler-based end uses is 6 million barrels and 9 million barrels, respectively. Therefore, we assume that the boiler/engine split for industrial distillate is 60% boilers and 40% engines.

The default boiler/engine split assumptions for commercial distillate consumption were calculated using data from EIA's *Commercial Building Energy Consumption Survey (CBECS)*, Table E9 [ref 7], which provides data on distillate consumption by end use for the commercial sector. It is assumed that space heating and water heating are associated with boilers (211 trillion Btu) and "other" is associated with engines (10 trillion Btu). The result is a default boiler/engine split for commercial distillate of 95% boilers and 5% engines. Note that this approach may overestimate the number of engines in the commercial sector, since the "other" end use category could also include boilers. Nevertheless, the data show that the vast majority of distillate consumption in the commercial sector is for space and water heating.

Table 4-66: Default assumptions for distillate boiler/engine splits

	Industrial	**Commercial/Institutional**
Boiler	60%	95%
Engine	40%	5%

Non-fuel specific adjustments

Some industrial sector energy is consumed for non-fuel purposes, such as natural gas that is used as a feedstock in chemical manufacturing plants and to make nitrogenous fertilizer, and LPG that is used to create intermediate products that are ultimately made into plastics. To estimate the volume of fuel that is associated with industrial combustion, it is necessary to subtract the volume of fuel consumption for non-energy uses from the volume of total fuel consumption.

The identification of feedstock usage was initially based upon the non-fuel use assumptions incorporated into the EIA's GHG emissions inventory for 2005 [ref 5]. The following fuels are assumed to be used entirely for non-fuel purposes: asphalt and road oil, feedstocks (naphtha <401 °F), feedstocks (other oils >401 °F), lubricants, miscellaneous petroleum products, pentanes plus, special naphthas, and waxes. In addition, it is also assumed that kerosene and motor gasoline are used entirely as fuel without any non-fuel purposes. The remaining fuels (i.e., coal [non-coke], distillate oil, LPG, natural gas, and residual oil) are used both for fuel and non-fuel purposes. The regional non-fuel fractions for distillate oil, LPG, natural gas, non-coke coal and residual oil are derived from non-fuel (feedstock) and total energy use statistics contained in EIA's 2010 Manufacturing Energy Consumption Survey (MECS) [ref 6] and are presented in Table 4-67. Note, non-fuel use of distillate fuel oil was not reported at the regional level; therefore, the default nonfuel use fractions are based on national nonfuel use of distillate fuel oil. In addition, non-fuel use was reported in EIA data as "less than 0.5" for non-coke coal, LPG and residual oil in West and residual coal in the northeast; in these cases, a value of 0.25 was used to estimate the default nonfuel use fractions.

Table 4-67: Industrial sector percent of total energy consumption from non-fuel use estimates

Fuel	**Northeast**	**Midwest**	**South**	**West**

Non-Coke Coal	63	38	26	4
Natural Gas	1	5	14	2
LPG	33	88	99	6
Distillate Oil	4	4	4	4
Residual Oil	5	50	68	20

Point source energy adjustments

To ensure that fuel consumption is not double-counted in the point source inventory, it is also necessary to subtract point source inventory fuel use from the fuel consumption estimates developed from the above steps. Equation 2 illustrates the approach to performing point source subtractions.

$$N_{s,f} = T_{s,f} - P_{s,f} \qquad (2)$$

where:

- N = nonpoint fuel consumption,
- T = total fuel consumption,
- P = point source fuel consumption,
- s = sector (Industrial or Commercial/Institutional),
- f = fuel type (coal, natural gas, distillate oil, residual oil, liquefied petroleum gas, kerosene and wood).

The first step in the point source subtraction procedure is to identify how each ICI combustion nonpoint source classification code (SCC) links to associated ICI combustion point SCCs. The ICI Combustion Tool includes two such crosswalks: one between each Industrial fuel combustion nonpoint SCC and related point SCCs, and an analogous crosswalk developed for Commercial/Institutional fuel combustion SCCs. One issue to note is that natural gas consumed as pipeline fuel is not included by the SEDS within the Industrial sector. Therefore, it is necessary to exclude pipeline natural gas consumption in performing natural gas combustion subtraction. This consumption may be included within industrial sector natural gas internal combustion engine records (SCC 202002xx).

An issue that must be considered is the geographic resolution at which point source subtractions should be performed. While locations of point sources are accurately known at (and below) the county-level, total ICI combustion activity is much less clear. Because of the level of uncertainty associated with the county distribution of total ICI fuel consumption, S/L/Ts may wish to perform the ICI combustion point source subtractions at the state-level, and then allocate the resulting nonpoint source fuel consumption to counties. On the contrary, if S/L/Ts have more accurate county-level fuel consumption values then point source subtraction can be performed at the county-level. The ICI Tool is designed to prioritize county-level data over state-level data, so where county-level data exists, the ICI Tool will perform county-level subtractions before using state-level data.

If an agency does not have county- or state-level point source activity data, emissions data can be used in the place of activity data in the point source subtraction procedure. The procedure follows the same steps, except that the emissions are calculated first, and then the point source activity data are subtracted from the total emissions.

4.12.3.2 *County allocation of state activity*

Because the EIA only reports energy consumption down to the state-level, it is necessary to develop a procedure to allocate EIA's fuel consumption estimates (after adjustments noted in sections above) to counties. For the NEI, the procedure relies on the use of allocation factors developed from the county-level number of employees in the Industrial sector and the county number of employees in the Commercial/Institutional sector. Because EIA fuel consumption data originate from fuel sector-specific surveys of energy suppliers,[9] we reviewed these survey forms/instructions for further details on what individual economic sectors EIA considers comprising the Industrial and Commercial sector. Based on this review, we compiled employment data for manufacturing sector North American Industrial Classification System (NAICS) codes (i.e., NAICS 31-33) for use in allocating Industrial fuel combustion. The only source of NAICS-code based EIA definitions of the Commercial energy sector is a "rough crosswalk" between Commercial building types and NAICS codes developed for EIA's Commercial Building Energy Consumption Survey (CBECS) [ref 7]. Except for NAICS code 814 (Private Households), this crosswalk links all NAICS codes between 42 and 92 with Commercial building energy consumption.

The ICI Combustion Tool compiles employment data for these NAICS codes from two Bureau of the Census publications –*County Business Patterns* (for private sectors), and *Census of Governments* (for public administration sectors) [ref 8, ref 9]. For NAICS code 92, county-level employment is estimated from local government employment data in the *Census of Governments*.[10] Employment estimates from each source are then combined to estimate total Commercial/ Institutional sector employment by county. The state-level fuel combustion by fuel type estimates in each sector are then allocated to each county using the ratio of the number of Industrial or Commercial/Institutional employees in each county in each state.

Due to concerns with releasing confidential business information, County Business Patterns (CBP) withholds values for a given county/NAICS code if it would be possible to identify data for individual facilities. In such cases, the Census reports a letter code, representing a particular employment size range. We used the following procedure to estimate data for withheld counties/NAICS codes.

1. County-level employment for counties with reported values are totaled by state for the applicable NAICS code.
2. The value from step 1 is subtracted from the state employment value for the NAICS code.
3. Each of the withheld counties is assigned an initial employment estimate reflecting the midpoint of the CBP range code (e.g., code A, which reflects 1-19 employees, is assigned an estimate of 10 employees).
4. The initial employment estimates from step 3 are then summed to the state level.
5. The value from step 2 is divided by the value from step 4 to yield an adjustment factor to apply to the initial employment estimates to yield employment values that will sum to the state employment total for the applicable NAICS code.
6. The final county-level employment values are estimated by multiplying the initial employment estimates from step 3 by the step 5 adjustment factors.

Table 4-68 illustrates the employment estimation procedure with an example of CBP data reported for Maine.

Table 4-68: NAICS Code 31-33 (Manufacturing) employment data for Maine

FIPSSTATE	FIPSCTY	NAICS	EMPFLAG	EMP
23	1	31----		6,774

[9] For natural gas, for example – EIA-176 "Annual Report of Natural and Supplemental Gas Supply and Disposition."

[10] County-level federal and state government employment data are not available from the Bureau of the Census.

FIPSSTATE	FIPSCTY	NAICS	EMPFLAG	EMP
23	3	31----		3,124
23	5	31----		10,333
23	7	31----		1,786
23	9	31----		1,954
23	11	31----		2,535
23	13	31----		1,418
23	15	31----	F	0
23	17	31----		2,888
23	19	31----		4,522
23	21	31----		948
23	23	31----	I	0
23	25	31----		4,322
23	27	31----		1,434
23	29	31----		1,014
23	31	31----		9,749

- The total of employees not including counties 015 and 023 is 52,801.
- *County Business Patterns* reports 59,322 state employees in NAICS 31—the difference is 6,521.
- County 015 is given a midpoint of 1,750 (since range code F is 1,000-2,499) and County 023 is given a midpoint of 17,500.
- State total for these two counties is 19,250.
- 6,521/19,250 = 0.33875.

The final employment estimate for county 015 is 1,750 x 0.33875 = 593. The county 023 final employment estimate is computed as 17,500 x 0.33875 = 5,928.

4.12.3.3 *Emission factors*

Table 4-69 lists the CAP emission factors used in the ICI Combustion Tool. The CAP and HAP emission factors for each nonpoint source fuel combustion category included in the ICI Combustion Tool are primarily EPA emission factors. Most of the emission factors are from the EPA/ERTAC2 database and EPA's *AP-42* report, Compilation of Air Pollutant Emission Factors [ref 10, ref 11]. The ammonia emission factors for wood combustion are from an Emission Inventory Improvement Program (EIIP) guidance document [ref 12].

For coal combustion, the SO_2 emission factors are based on the sulfur content of the coal burned, and some of the PM emission factors for anthracite coal require information on the ash content of the coal. For the industrial and commercial/institutional sectors, state-specific coal sulfur contents for bituminous coal are obtained from the EIA's quarterly coal report [ref 13]. For anthracite coal, an ash content value of 13.38% and a sulfur content of 0.89% are applied to all states.

Table 4-69: CAP emission factors for ICI source categories

SCC	Description	Emission Factor Units[1]	VOC	NO_x	CO	SO_2	PM25-FIL	PM10-FIL	PM-CON	NH_3
2102001000	Industrial Anthracite Coal	lb/ton	0.3	9	0.6	39 * S%	0.48 * A%	1.1 * A%	0.08*A%	0.03
2102002000	Industrial Bitum/Subbitum Coal	lb/ton	0.05	11	5	38 * S%	1.4	12	1.04	0.03
2102004000	Industrial Distillate Oil	lb/1000 gal	0.2	20	5	142 * S%	0.25	1	1.3	0.8
2102005000	Industrial Residual Oil	lb/1000 gal	0.28	55	5	157 * S%	4.67 * (1.12 * S% + 0.37)	7.17 * (1.12 * S% + 0.37)	1.5	0.8
2102006000	Industrial Natural Gas	lb/MMcf	5.5	100	84	0.6	0.11	0.2	0.322	3.2
2102007000	Industrial LPG [3]	lb/1000 gal	0.52	14.2	8	0.06	0.01	0.02	0.03	0.34
2102008000	Industrial Wood [5]	lb/MMBtu	0.02	0.22	0.6	0.025	0.43	0.5	0.017	0.008
2102011000	Industrial Kerosene	lb/1000 gal	0.19	19.3	4.8	142 * S%[7]	0.24	0.96	1.25	0.77
2103001000	Comm/Inst Anthracite Coal	lb/ton	0.3	9	0.6	39 * S%	0.48 * A%	1.1 * A%	0.08 * A%	0.03
2103002000	Comm/Inst Bitum/Subbitum Coal	lb/ton	0.05	11	5	38 * S%	1.4	12	1.04	0.03
2103004000	Comm/Inst Distillate Oil	lb/1000 gal	0.34	20	5	142 * S%	0.83	1.08	1.3	0.8
2103005000	Comm/Inst Residual Oil	lb/1000 gal	1.13	55	5	157 * S%	1.92 * (1.12 * S% + 0.37)	5.17 * (1.12 * S% + 0.37)	1.5	0.8
2103006000	Comm/Inst Natural Gas	lb/MMcf	5.5	100	84	0.6	0.11	0.2	0.32	0.49
2103007000	Comm/Inst LPG	lb/1000 gal	0.52	14.2	8	0.06	0.01	0.02	0.03	0.05

SCC	Description	Emission Factor Units[1]	VOC	NO_x	CO	SO_2	PM25-FIL	PM10-FIL	PM-CON	NH_3
2103008000	Comm/Inst Wood [5]	lb/MMBtu	0.02	0.22	0.6	0.025	0.43	0.5	0.017	0.006
2103011000	Comm/Inst Kerosene	lb/1000 gal	0.33	19.3	4.8	142 * S%	0.8	1.04	1.3	0.8

Source: Unless otherwise noted, ERTAC emission factors used to support the 2011 NEI [ref 10].

Notes: [1] lb = pound; ton = short ton; gal = gallon; MMcf = million cubic feet; MMBtu = million British thermal units; bbl = barrels; S% = percent sulfur content; A% = percent ash content

[2] The EPA ERTAC emission factor workbook [ref 10] for this emission factors (EF) contains an error. The change log in the ERTAC workbook conflicts with the actual changes made to the emission factors spreadsheet. The PM-CON EF should be 0.32 lb/MMcf for 2102006000 instead of the 0.49 lb/MMcf value reported in the ERTAC workbook.

[3] Emission factors from Commercial/Institutional LPG.

[4] The EPA ERTAC emission factor workbook [ref 10] for this emission factors (EF) contains an error. The change log in the ERTAC workbook conflicts with the actual changes made to the emission factors spreadsheet. The NH_3 EF should be 0.3 lb/1000 gal for 2102007000 instead of the 0.05 lb/1000 gal value reported in the ERTAC workbook.

[5] Emission factors from *AP-42*, Section 1.6, Wood Residue Combustion in Boilers [ref 4].

[6] Emission factor from Pechan, 2004 [ref 12] (converted from lb/ton using 0.08 ton/MMBtu for Industrial sector and 0.0625 ton/MMBtu for Commercial sector).

[7] The EPA ERTAC emission factor workbook [ref 10] for this emission factors (EF) contains an error. The ERTAC workbook uses the equation 157*S%. The correct EF equation is 142*S%.

In the ICI Tool, users may edit the assumptions about the sulfur and ash content of fuels, using the form "Sulfur and Ash Content of Fuels" from the "Edit Assumptions" form. Assumptions about sulfur content can be adjusted at the state level for bituminous/subbituminous coal, anthracite coal, residual oil, and distillate oil. Sulfur content assumptions can also be adjusted at the county level for distillate oil. Assumptions about ash content can be adjusted at the state level for anthracite coal.

4.12.3.4 *ICI Tool changes in the 2014v2 NEI*

In addition to updating the default distillate oil boiler/engine split (see Table 4-66) for the 2014v2 NEI, users may now also add user defined control efficiencies for each SCC in each county, using the "Control Efficiencies for Nonpoint SCCs" table, which can be accessed from the "Edit Assumptions" form. Control efficiencies entered into this table are used to adjust the final reported emissions using the following equation:

$$Controlled\ Nonpoint\ Emissions_{s,c} = Uncontrolled\ Nonpoint\ Emissions_{s,c} \times (1 - Control\ Efficiency_{s,c})$$

Where *Controlled Nonpoint Emissions* are the final reported nonpoint emissions, *Uncontrolled Nonpoint Emissions* are the emissions estimated after point source subtraction but before the application of the control efficiency, *Control Efficiency* is the user-supplied control efficiency, *s* is SCC, and *c* is county.

Note that the control efficiency must be a number between 0 and 1. The default control efficiencies in the tool are 0 for all counties and SCCs.

4.12.3.5 *Known Issues in the 2014v2 NEI*

EPA accidentally left state-submitted double-counts for both Industrial (SCC 2102004000) and Commercial/Institutional (SCC 2103004000) Distillate Oil - Total Boilers and IC Engines in New Jersey. This yields approximately 1,000 tons of both NOX and SO2 that are already accounted for in the engine-specific and boiler-specific ICI distillate oil SCCs. EPA plans to incorporate a selection procedure in the 2017 NEI that will prevent the mixing of these specific and more general SCCs/double-counts. In addition, with very few large ICI sources not including some type of control device, we plan to significantly restrict, or remove, the ability to compute nonpoint ICI emissions by simple point inventory emission subtraction; but rather, require point inventory throughput (activity data) subtraction.

4.12.4 References for ICI fuel combustion

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4.13 Fuel Combustion – Residential – Natural Gas, Oil and Other

4.13.1 Sector description

The EIS sectors to be documented here are:

- "Fuel Comb - Residential - Natural Gas" which includes the fuel natural gas only. Residential natural gas combustion is natural gas that is burned to heat residential housing as well as in grills, hot water heaters, and dryers.
- "Fuel Comb - Residential – Oil" which includes the fuels: (1) distillate oil, (2) kerosene and (3) residual oil. Residual oil is not an EPA-estimated category, and no agencies submitted data for it in 2014. Residential distillate oil combustion is oil that is burned in residential housing. Residential kerosene combustion is kerosene that is burned in residential housing. Common uses of energy associated with this sector include space heating, water heating, cooking, and running a wide variety of other equipment.
- "Fuel Comb - Residential – Other" which includes the fuels: (1) coal, (2) liquid petroleum gas (LPG) and (3) "Biomass; all except Wood". Note that "Biomass; all except Wood" is not an EPA-estimated category, and no S/L/T agency submitted data for it for the 2014 NEI. Residential Coal Combustion is coal that is burned to heat residential housing. Residential LPG combustion is liquefied propane gas that is burned in residential housing. Common uses of energy associated with this sector include space heating, water heating, and cooking.

4.13.2 Sources of data

Table 4-70 shows, for non-wood Residential heating, the nonpoint SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 3 and 4 SCC descriptions are also provided. The SCC level 1 and 2 descriptions is "Stationary Source Fuel Combustion; Residential" for all SCCs.

According to the State Energy Data System (SEDS) 2013 Consumption tables published by the Energy Information Administration (EIA) [ref 1], there was no residential coal combustion in 2013. However, the old methodology is retained here and provided in an EPA workbook, and as seen in Table 4-70, with zero emissions, in case a state would like to use their own coal consumption data.

Table 4-70: Non-wood residential heating SCCs with 2014 NEI emissions

Sector Fuel	SCC	Description	EPA	State	Local	Tribe
Natural Gas	2104006000	Natural Gas; Total: All Combustor Types	X	X	X	X
Oil	2104004000	Distillate Oil; Total: All Combustor Types	X	X	X	X
Oil	2104011000	Kerosene; Total: All Heater Types	X	X	X	X
Other	2104001000	Anthracite Coal; Total: All Combustor Types	0	0		0
Other	2104002000	Bituminous/Subbituminous Coal; Total: All Combustor Types	0	X		X
Other	2104007000	Liquified Petroleum Gas (LPG); Total: All Combustor Types	X	X	X	X

The agencies listed in Table 4-71 submitted emissions for these sectors; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-71: Percentage of non-wood residential heating NO_X, $PM_{2.5}$ and VOC emissions submitted by reporting agency

Region	Agency	S/L/T	Sector Fuel	NO_X	$PM_{2.5}$	VOC
1	Massachusetts Department of Environmental Protection	State	Natural Gas	100	100	100
1	Massachusetts Department of Environmental Protection	State	Oil	100	100	100
1	Massachusetts Department of Environmental Protection	State	Other	100	100	100
1	New Hampshire Department of Environmental Services	State	Natural Gas	100	99	100
1	New Hampshire Department of Environmental Services	State	Oil	100	100	100
1	New Hampshire Department of Environmental Services	State	Other	100	100	100
1	Vermont Department of Environmental Conservation	State	Natural Gas	100		100
2	New Jersey Department of Environment Protection	State	Natural Gas	100	100	100
2	New Jersey Department of Environment Protection	State	Oil	100	100	100
2	New Jersey Department of Environment Protection	State	Other	100	100	100
2	New York State Department of Environmental Conservation	State	Natural Gas	100	100	100
2	New York State Department of Environmental Conservation	State	Oil	100	100	100
2	New York State Department of Environmental Conservation	State	Other	100	100	100
3	Delaware Department of Natural Resources and Environmental Control	State	Natural Gas	100	100	100
3	Delaware Department of Natural Resources and Environmental Control	State	Oil	100	100	100
3	Delaware Department of Natural Resources and Environmental Control	State	Other	100	100	100
3	Maryland Department of the Environment	State	Natural Gas	100		100
3	Maryland Department of the Environment	State	Oil	100	100	100
3	Maryland Department of the Environment	State	Other	100	28	100
3	Virginia Department of Environmental Quality	State	Natural Gas	100	100	100
3	Virginia Department of Environmental Quality	State	Oil	100	100	100
3	Virginia Department of Environmental Quality	State	Other	100	100	100
4	Metro Public Health of Nashville/Davidson County	State	Natural Gas	100		100
4	Metro Public Health of Nashville/Davidson County	State	Oil	90		89
4	Metro Public Health of Nashville/Davidson County	State	Other	100		100
5	Illinois Environmental Protection Agency	State	Natural Gas	100	100	100
5	Illinois Environmental Protection Agency	State	Oil	100	100	100
5	Illinois Environmental Protection Agency	State	Other	100	100	100

Region	Agency	S/L/T	Sector Fuel	NO_X	$PM_{2.5}$	VOC
5	Michigan Department of Environmental Quality	State	Natural Gas	100		100
5	Michigan Department of Environmental Quality	State	Oil	100		100
5	Michigan Department of Environmental Quality	State	Other	100		100
6	Texas Commission on Environmental Quality	State	Natural Gas	100	100	100
6	Texas Commission on Environmental Quality	State	Oil	100	100	
6	Texas Commission on Environmental Quality	State	Other	100	100	100
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	Other	100		100
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	Tribe	Natural Gas	100		100
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	Tribe	Other	100		100
8	Northern Cheyenne Tribe	Tribe	Natural Gas	100		100
8	Northern Cheyenne Tribe	Tribe	Oil	100		100
8	Northern Cheyenne Tribe	Tribe	Other	100		100
8	Utah Division of Air Quality	State	Natural Gas	100	100	100
8	Utah Division of Air Quality	State	Other	100	100	100
9	Arizona Department of Environmental Quality	State	Natural Gas	100	100	100
9	Arizona Department of Environmental Quality	State	Oil	100	100	100
9	Arizona Department of Environmental Quality	State	Other	100	100	100
9	California Air Resources Board	State	Natural Gas	100	100	100
9	California Air Resources Board	State	Oil	89	90	96
9	California Air Resources Board	State	Other	100	100	100
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	Tribe	Natural Gas	100		100
9	Washoe County Health District	Local	Natural Gas	100		100
9	Washoe County Health District	Local	Oil	100		100
9	Washoe County Health District	Local	Other	100		100
10	Alaska Department of Environmental Conservation	State	Natural Gas	9		6
10	Coeur d'Alene Tribe	Tribe	Natural Gas	100	100	100
10	Coeur d'Alene Tribe	Tribe	Oil	100	100	100
10	Coeur d'Alene Tribe	Tribe	Other	100	100	100
10	Idaho Department of Environmental Quality	State	Natural Gas	100	100	100
10	Idaho Department of Environmental Quality	State	Oil	100	100	100
10	Idaho Department of Environmental Quality	State	Other	100	100	100
10	Kootenai Tribe of Idaho	Tribe	Natural Gas	100	100	100
10	Kootenai Tribe of Idaho	Tribe	Oil	100	100	100
10	Kootenai Tribe of Idaho	Tribe	Other	100	100	100
10	Nez Perce Tribe	Tribe	Natural Gas	100	100	100
10	Nez Perce Tribe	Tribe	Oil	100	100	100
10	Nez Perce Tribe	Tribe	Other	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	Natural Gas	100	100	100

Region	Agency	S/L/T	Sector Fuel	NO_X	$PM_{2.5}$	VOC
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	Oil	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	Other	100	100	100

4.13.3 EPA-developed emissions for residential heating – natural gas, oil and other fuels

The general approach to calculating emissions for all fuel types is to take state-level fuel-specific (natural gas, distillate oil, kerosene, coal, and LPG) consumption from the EIA and allocate it to the county level using the methods described below. County-level fuel consumption is multiplied by the emission factors to calculate emissions.

4.13.3.1 *Activity data: new for 2014v2*

Natural Gas, Distillate Oil, Kerosene, and LPG

The state-level volume of each of these fuel types consumed by residential combustion in the United States was used to estimate emissions. Fuel type consumption by energy use sector was obtained from the State Energy Data System (SEDS) 2014 Consumption tables published by the EIA [ref 1]. Year 2013 consumption data were used in 2014v1 because these data were the latest data available when the 2014v1 inventory was prepared.

Natural gas consumption is represented in the SEDS table by the Data Series Name (MSN) NGRCP. Distillate consumption is represented in the SEDS table by the Data Series Name (MSN) DFRCP. Kerosene consumption is represented in the SEDS table by the Date Series Name (MSN) KSRCP. LPG consumption is represented in the SEDS table by the Data Series Name (MSN) LGRCP.

State-level fuel type consumption was allocated to each county using the US Census Bureau's 2014 5-year estimate Census Detailed Housing Information [ref 2]; for 2014v1, a 2013 5-year estimate was used. These data include the number of housing units using a specific type of fuel for residential heating. State fuel type consumption was allocated to each county using the ratio of the number of houses burning natural gas, distillate oil, kerosene, or LPG in each county to the total number of houses burning natural gas, distillate oil, kerosene, or LPG in the state.

Coal

The mass of coal consumed by residential combustion in the U.S. was used to estimate emissions. Coal consumption by energy use sector is presented in State Energy Data System (SEDS) 2014 Consumption tables published by the Energy Information Administration (EIA) [ref 1]. Year 2013 consumption data were used in 2014v1 because these data were the latest data available when the 2014v1 inventory was prepared. Coal consumption is represented in the SEDS table by the Data Series Name (MSN) CLRCP.

EIA data do not distinguish between anthracite and bituminous coal consumption estimates. The EIA table "Domestic Distribution of U.S. Coal by Destination State, Consumer, Origin and Method of Transportation," provides state-level residential coal distribution data for 2006 that was used to estimate anthracite and bituminous coal consumption. The amount of anthracite distributed to each state and the total coal delivered to each state were used to estimate the proportion of anthracite and bituminous coal consumption [ref 3]. The 2006 ratio of anthracite (and bituminous) coal consumption to total coal consumption was used to distribute the EIA's total residential sector coal consumption data by coal type. Table 4-72 presents the 2006-based percent of total bituminous coal for each state. The percent anthracite coal is computed as the remaining percent (if any).

Table 4-72: 2006 percent bituminous coal distribution for the residential and commercial sectors

State	Percent Bituminous	State	Percent Bituminous
Alabama	100	Montana	100
Alaska	100	Nebraska	100
Arizona	81.4	Nevada	100
Arkansas	81.4	New Hampshire	0
California	100	New Jersey	0
Colorado	99.6	New Mexico	100
Connecticut	0	New York	60
Delaware	81.4	North Carolina	100
Dist. Columbia	100	North Dakota	100
Florida	81.4	Ohio	87.3
Georgia	100	Oklahoma	91.7
Hawaii	100	Oregon	100
Idaho	97.9	Pennsylvania	19.4
Illinois	99.8	Rhode Island	0
Indiana	94.7	South Carolina	99.7
Iowa	99.9	South Dakota	100
Kansas	100	Tennessee	99.4
Kentucky	99.8	Texas	81.4
Louisiana	100	Utah	100
Maine	0	Vermont	0
Maryland	92.9	Virginia	96.3
Massachusetts	50	Washington	100
Michigan	66.7	West Virginia	90.5
Minnesota	99.7	Wisconsin	99.1
Mississippi	100	Wyoming	100
Missouri	100		

State-level coal consumption was allocated to each county using the US Census Bureau's 2014 5-year estimate Census Detailed Housing Information [ref 2]; for 2014v1, a 2013 5-year estimate was used. These data include the number of housing units using a specific type of fuel for residential heating. State coal consumption was allocated to each county using the ratio of the number of houses burning coal in each county to the total number of houses burning coal in the state.

4.13.3.2 *Control factors*

No control measures are assumed for any non-wood residential heating sources.

4.13.3.3 *Emission factors*

Natural Gas

Criteria pollutant emission factors for natural gas are from AP-42 [ref 4]. The ammonia emission factor is from EPA's *Estimating Ammonia Emissions from Anthropogenic Sources, Draft Final Report* [ref **Error! Reference source not found.**]. HAP emission factors are from AP-42 and "Documentation for the 1999 Base Year Nonpoint

Area Source National Emission Inventory for Hazardous Air Pollutants." [ref 6] According to AP-42 (maximum value provided) [ref 4], natural gas has a heat content of 1,050 million BTU per million cubic feet. This value was required to convert those emission factors originally given in units "pounds per million Btu" to units "pounds per million cubic feet." The grains of sulfur per million cubic feet are assumed to be 2000 [ref 7]. Some emission factors were revised based on recommendations by an ERTAC advisory panel composed of state and EPA personnel.

County-level criteria pollutant and HAP emissions were calculated by multiplying the total natural gas consumed in each county per year by an emission factor. Table 4-73 provides a summary of the pollutants, pollutant codes, and emission factors for residential combustion of natural gas.

Table 4-73: Residential natural gas combustion emission factors

Pollutant Code	Pollutant Code Description	Emission Factor (LB/E6FT3)
129000	PYRENE	0.00000525
206440	FLUORANTHENE	0.00000315
50000	FORMALDEHYDE	0.07875
71432	BENZENE	0.002205
75070	ACETALDEHYDE	0.00001365
85018	PHENANTHRENE	0.00001785
86737	FLUORENE	0.00000294
91203	NAPHTHALENE	0.0006405
CO	CARBON MONOXIDE	40
NH3	AMMONIA	20
NOX	NITROGEN OXIDES	94
PM10-PRI	PRIMARY PM_{10} (INCLUDES FILTERABLES + CONDENSIBLES)	0.52
PM25-PRI	PRIMARY $PM_{2.5}$ (INCLUDES FILTERABLES + CONDENSIBLES)	0.43
PM10-FIL	PRIMARY PM_{10}, FILTERABLE PORTION ONLY	0. 2
PM25-FIL	PRIMARY $PM_{2.5}$, FILTERABLE PORTION ONLY	0.11
PM-CON	PRIMARY PM CONDENSIBLE PORTION ONLY	0.32
SO2	SULFUR DIOXIDE	0.6
VOC	VOLATILE ORGANIC COMPOUNDS	5.5

<u>Distillate Oil</u>

Criteria pollutant emission factors for distillate oil are from AP-42 [ref 4]. For all counties in the United States, the distillate oil consumed by residential combustion is assumed to be No. 2 fuel oil with a heating value of 140,000 Btu per gallon and a sulfur content of 0.30% [ref 7]. Dioxin/furan and HAP emission factors are from "Documentation of Emissions Estimation methods for Year 2000 and 2001 Mobile Source and Nonpoint Source Dioxin Inventories" [ref 8] and "Documentation for the 1999 Base Year Nonpoint Area Source National Emission Inventory for Hazardous Air Pollutants," [ref 6] respectively. Sulfur content was 0.30% and was obtained from data compiled in preparing the 1999 residential coal combustion emissions estimates [ref 7]. The ammonia emission factor is from EPA's *Estimating Ammonia Emissions from Anthropogenic Sources, Draft Report* [ref **Error! Reference source not found.**]. Table 4-74 provides a summary of the pollutants, pollutant codes, and emission factors for residential combustion of distillate oil.

Table 4-74: Residential distillate oil combustion emission factors

Pollutant Code	Pollutant Code Description	Emissions Factor (LB/E3GAL)	Reference
120127	ANTHRACENE	1.22E-06	6
129000	PYRENE	4.21E-06	6
1746016	2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	4.66E-10	8
191242	BENZO[G,H,I,]PERYLENE	2.25E-06	6
193395	INDENO[1,2,3-C,D]PYRENE	2.11E-06	6
206440	FLUORANTHENE	4.92E-06	6
208968	ACENAPHTHYLENE	2.53E-07	6
218019	CHRYSENE	2.39E-06	6
3268879	OCTACHLORODIBENZO-P-DIOXIN	5.49E-10	8
39001020	OCTACHLORODIBENZOFURAN	2.50E-10	8
50000	FORMALDEHYDE	3.37E-02	6
51207319	2,3,7,8-TETRACHLORODIBENZOFURAN	4.41E-10	8
53703	DIBENZO[A,H]ANTHRACENE	1.69E-06	6
56553	BENZ[A]ANTHRACENE	4.07E-06	6
71432	BENZENE	2.11E-04	6
7439921	LEAD	1.26E-03	6
7439965	MANGANESE	8.43E-04	6
7439976	MERCURY	4.21E-04	6
7440020	NICKEL	4.21E-04	6
7440382	ARSENIC	5.62E-04	6
7440417	BERYLLIUM	4.21E-04	6
7440439	CADMIUM	4.21E-04	6
16065831	Chromium III	0.000345556	
18540299	Chromium (VI)	7.58538E-05	
75070	ACETALDEHYDE	4.92E-03	6
7782492	SELENIUM	2.11E-03	6
83329	ACENAPHTHENE	2.11E-05	6
85018	PHENANTHRENE	1.05E-05	6
86737	FLUORENE	4.50E-06	6
91203	NAPHTHALENE	1.14E-03	6
CO	CARBON MONOXIDE	5.00E+00	8
NH3	AMMONIA	1.00E+00	5
NOX	NITROGEN OXIDES	1.80E+01	4
PM10-FIL	PRIMARY PM_{10}, FILTERABLE PORTION ONLY	1.08E+00	4
PM10-PRI	PRIMARY PM_{10} (INCLUDES FILTERABLES + CONDENSIBLES)	2.38E+00	4
PM25-FIL	PRIMARY $PM_{2.5}$, FILTERABLE PORTION ONLY	8.30E-01	4
PM25-PRI	PRIMARY $PM_{2.5}$ (INCLUDES FILTERABLES + CONDENSIBLES)	2.13E+00	4
PM-CON	PRIMARY PM CONDENSIBLE PORTION ONLY (< 1 MICRON)	1.30E+00	4
SO2	SULFUR DIOXIDE	4.26E+01	4
VOC	VOLATILE ORGANIC COMPOUNDS	7.00E-01	4

Kerosene

Emission factors for distillate oil were used for kerosene, but the distillate oil emission factors were multiplied by a factor of 135/140 to convert them for this use. This factor is based on the ratio of the heat content of kerosene (135,000 Btu/gallon) to the heat content of distillate oil (140,000 Btu/gallon) [ref 4]. Criteria pollutant emission factors are from AP-42. [ref 4]. Dioxin/furan and HAP emission factors are from "Documentation of Emissions Estimation methods for Year 2000 and 2001 Mobile Source and Nonpoint Source Dioxin Inventories" [ref 8] and "Documentation for the 1999 Base Year Nonpoint Area Source National Emission Inventory for Hazardous Air Pollutants," [ref 6] respectively. Distillate sulfur content (0.30%) was used for kerosene as well [ref 7]. Table 4-75 provides a summary of the pollutants, pollutant codes, and emission factors for residential combustion of kerosene.

Table 4-75: Residential kerosene combustion emission factors

Pollutant Code	Pollutant Code Description	Emissions Factor (LB/E3BBL)
120127	ANTHRACENE	4.95E-05
129000	PYRENE	0.00017067
1746016	2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	1.89E-08
191242	BENZO[G,H,I,]PERYLENE	9.10E-05
193395	INDENO[1,2,3-C,D]PYRENE	8.53E-05
206440	FLUORANTHENE	0.00019912
208968	ACENAPHTHYLENE	1.02E-05
218019	CHRYSENE	9.67E-05
3268879	OCTACHLORODIBENZO-P-DIOXIN	2.22E-08
39001020	OCTACHLORODIBENZOFURAN	1.01E-08
50000	FORMALDEHYDE	1.3653684
51207319	2,3,7,8-TETRACHLORODIBENZOFURAN	1.79E-08
53703	DIBENZO[A,H]ANTHRACENE	6.83E-05
56553	BENZ[A]ANTHRACENE	0.00016498
71432	BENZENE	0.00853355
7439921	LEAD	0.05120132
7439965	MANGANESE	0.03413421
7439976	MERCURY	0.01706711
7440020	NICKEL	0.01706711
7440382	ARSENIC	0.02275614
7440417	BERYLLIUM	0.01706711
7440439	CADMIUM	0.01706711
16065831	Chromium III	0.013995026
18540299	Chromium (VI)	0.003072079
75070	ACETALDEHYDE	0.19911623
7782492	SELENIUM	0.08533553
83329	ACENAPHTHENE	0.00085336
85018	PHENANTHRENE	0.00042668
86737	FLUORENE	0.00018205
91203	NAPHTHALENE	0.04608118

Pollutant Code	Pollutant Code Description	Emissions Factor (LB/E3BBL)
NH3	AMMONIA	40.5
CO	CARBON MONOXIDE	202.5
NOX	NITROGEN OXIDES	729
PM10-PRI	PRIMARY PM_{10} (INCLUDES FILTERABLES + CONDENSIBLES)	96.39
PM25-PRI	PRIMARY $PM_{2.5}$ (INCLUDES FILTERABLES + CONDENSIBLES)	86.265
PM10-FIL	PRIMARY PM_{10}, FILTERABLE PORTION ONLY	43.74
PM25-FIL	PRIMARY $PM_{2.5}$, FILTERABLE PORTION ONLY	33.615
PM-CON	PRIMARY PM CONDENSIBLE PORTION ONLY (ALL LESS THAN 1 MICRON)	52.65
SO2	SULFUR DIOXIDE	1,725.30
VOC	VOLATILE ORGANIC COMPOUNDS	28.35

Coal

All emission factors except ammonia are from AP-42 [ref 4]. The ammonia emission factor is from EPA's *Estimating Ammonia Emissions from Anthropogenic Sources, Draft Final Report* [ref **Error! Reference source not found.**].

Table 4-76 shows the SO_2 and PM emission factors. The SO_2 emission factors require information on the sulfur content of the coal burned, while some of the PM emission factors for anthracite coal require information on the ash content of the coal. State-specific sulfur and ash contents of anthracite and bituminous coal were obtained from data compiled in preparing the 1999 residential coal combustion emissions estimates [ref 7]. This study mostly relied on data obtained from US Geological Survey COALQUAL database. States not included in the database but that reported coal usage were assigned values based on their proximity to coal seams or using an average value for Pennsylvania (see report for details of the analysis). Note that the PM condensable emission factor provided in AP-42 is 0.04 lb/MMBtu. This was multiplied by the conversion factor of 26 MMBtu/ton provided in AP-42 for bituminous coal. Table 4-77 presents the bituminous coal sulfur content values used for each state. For anthracite coal, an ash content value of 13.38% and a sulfur content of 0.89% were applied to all states except New Mexico (ash content 16.61%, sulfur content 0.77%), Washington (ash content 12%, sulfur content 0.9%), and Virginia (ash content 13.38%, sulfur content 0.43%).

Table 4-76: SO_2 and PM emission factors for residential anthracite and bituminous coal combustion

Pollutant	Emission Factor (lb/ton)	Data Source, AP-42 [ref 4] Table No.
Anthracite Emission Factors (SCC 2104001000)		
PM-CON	0.08 * % Ash	1.2-3 (stoker)
PM10-FIL	10	1.2-3 (hand-fired)
PM25-FIL	4.6	Fig. 1.2-1 (ratio of $PM_{2.5}/PM_{10}$=1.25/2.70=0.46)
		0.46*10=4.6
PM10-PRI	10 + 0.08 * % Ash	1.2-3
PM25-PRI	4.6 + 0.08 * % Ash	1.2-3 and Fig 1.2-1
SO2	39 * % Sulfur	1.2-1 (residential space heater)
Bituminous Emission Factors (SCC 2104002000)		
PM-CON	1.04	1.1-5 (stoker)

Pollutant	Emission Factor (lb/ton)	Data Source, AP-42 [ref 4] Table No.
PM10-FIL	6.2	1.1-4 (hand-fed)
PM25-FIL	3.8	1.1-11 (underfeed stoker)
PM10-PRI	7.24	1.1-5 and 1.1-4
PM25-PRI	4.84	1.1-5 and 1.1-11
SO2	31 * % Sulfur	1.1-3 (hand-fed)
NOTE: PM_{10}, $PM_{2.5}$, and condensable PM emission factors for bituminous coal as well as filterable emission factors for PM_{10} and $PM_{2.5}$ for anthracite coal do not require ash content.		

Table 4-77: State-specific sulfur content for bituminous coal (SCC 2104002000)

State	Percent Sulfur Content	State	Percent Sulfur Content
Alabama	2.08	Montana	0.6
Alaska	0.31	Nebraska	2.43
Arizona	0.47	Nevada	2.3
Arkansas	1.2	New Hampshire	2.42
California	0.47	New Jersey	2.42
Colorado	0.61	New Mexico	0.75
Connecticut	2.42	New York	2.42
Delaware	1.67	North Carolina	1.62
District of Columbia	1.67	North Dakota	0.97
Florida	1.28	Ohio	3.45
Georgia	1.28	Oklahoma	3.08
Hawaii	1	Oregon	0.5
Idaho	0.31	Pennsylvania	2.42
Illinois	3.48	Rhode Island	2.42
Indiana	2.49	South Carolina	1.28
Iowa	4.64	South Dakota	0.97
Kansas	5.83	Tennessee	1.62
Kentucky	1.93	Texas	1.14
Louisiana	0.86	Utah	0.8
Maine	2.42	Vermont	2.42
Maryland	1.67	Virginia	1.19
Massachusetts	2.42	Washington	0.5
Michigan	1.2	West Virginia	1.25
Minnesota	0.97	Wisconsin	1
Mississippi	1.24	Wyoming	0.87
Missouri	3.39		

Table 4-78 presents a summary of the emission factors for residential anthracite coal combustion (SCC 2104001000) for all pollutants. Table 4-79 presents a summary of the emission factors for residential bituminous coal combustion (SCC 2104002000) for all pollutants. Note that the emission factor provided in AP-42 is 0.04 lb/MMBtu. This was multiplied by the conversion factor of 26 MMBtu/ton provided in AP-42 for bituminous coal.

Table 4-78: Residential anthracite coal combustion emission factors

Pollutant Code	Pollutant Code Description	Emissions Factor (LB/TON)	Data Source, AP-42 [ref 4] Table No.
83329	ACENAPHTHENE	0.000022	1.2-5
208968	ACENAPHTHYLENE	0.000086	1.2-5
120127	ANTHRACENE	0.000025	1.2-5
56553	BENZO[A]ANTHRACENE (Benz[a]Anthracene)	0.000071	1.2-5
50328	BENZO[A]PYRENE	0.0000053	1.2-5
192972	BENZO[E]PYRENE	0.0000062	1.2-5
191242	BENZO[G,H,I,]PERYLENE	0.0000055	1.2-5
207089	BENZO[K]FLUORANTHRENE (Benzo[k]Fluoranthene)	0.000025	1.2-5
218019	CHRYSENE	0.000083	1.2-5
206440	FLUORANTHRENE (Fluoranthene)	0.00017	1.2-5
86737	FLUORENE	0.000025	1.2-5
7647010	HYDROGEN CHLORIDE	1.2	1.1-15
7664393	HYDROGEN FLUORIDE	0.15	1.1-15
91203	NAPHTHALENE	0.00022	1.2-5
7439976	MERCURY	0.00013	1.2-7
198550	PERYLENE	0.0000012	1.2-5
85018	PHENANTHRENE	0.00024	1.2-5
129000	PYRENE	0.00012	1.2-5
CH4	METHANE	8	1.2-6
CO	CARBON MONOXIDE	275	1.1-3
NH3	AMMONIA	2	[ref **Error! Reference source not found.**]
NOX	NITROGEN OXIDES	3	1.2-1
PM10-FIL	PRIMARY PM_{10}, FILTERABLE PORTION	10	1.2-3
PM10-FIL	PRIMARY $PM_{2.5}$, FILTERABLE PORTION	4.6	1.2-3 & Fig 1.2-1
VOC	VOLATILE ORGANIC COMPOUNDS	10	1.1-19

Table 4-79: Residential bituminous coal combustion emission factors

Pollutant Code	Pollutant Code Description	Emissions Factor (LB/TON)	Data Source, AP-42 [ref 4] Table No.
532274	2-CHLOROACETOPHENONE	0.000007	1.1-14
121142	2,4-DINITROTOLUENE	0.00000028	1.1-14
3697243	5-METHLY CHRYSENE	2.2E-08	1.1-13
83329	ACENAPHTHENE	0.00000051	1.1-13
208968	ACENAPHTHYLENE	0.00000025	1.1-13
75070	ACETALDEHYDE	0.00057	1.1-14
98862	ACETOPHENONE	0.000015	1.1-14
107028	ACROLEIN	0.00029	1.1-14

Pollutant Code	Pollutant Code Description	Emissions Factor (LB/TON)	Data Source, AP-42 [ref 4] Table No.
120127	ANTHRACENE	0.00000021	1.1-13
56553	BENZ[A]ANTHRACENE	0.00000008	1.1-13
71432	BENZENE	0.0013	1.1-14
50328	BENZO[A]PYRENE	3.8E-08	1.1-13
191242	BENZO[G,H,I,]PERYLENE	2.7E-08	1.1-13
100447	BENZYL CHLORIDE	0.0007	1.1-14
92524	BIPHENYL	0.0000017	1.1-13
117817	BIS(2-ETHYLHEXYL)PHTHALATE	0.000073	1.1-14
75252	BROMOFORM	0.000039	1.1-14
75150	CARBON DISULFIDE	0.00013	1.1-14
108907	CHLOROBENZENE	0.000022	1.1-14
67663	CHLOROFORM	0.000059	1.1-14
218019	CHRYSENE	0.0000001	1.1-13
98828	CUMENE	0.0000053	1.1-14
57125	CYANIDE	0.0025	1.1-14
77781	DIMETHYL SULFATE	0.000048	1.1-14
100414	ETHYL BENZENE	0.000094	1.1-14
75003	ETHYL CHLORIDE	0.000042	1.1-14
106934	ETHYLENE DIBROMIDE	0.0000012	1.1-14
107062	ETHYLENE DICHLORIDE	0.00004	1.1-14
206440	FLUORANTHENE	0.00000071	1.1-13
86737	FLUORENE	0.00000091	1.1-13
50000	FORMALDEHYDE	0.00024	1.1-14
110543	HEXANE	0.000067	1.1-14
7647010	HYDROGEN CHLORIDE	1.2	1.1-15
7664393	HYDROGEN FLUORIDE	0.15	1.1-15
193395	INDENO[1,2,3-C,D]PYRENE	6.1E-08	1.1-13
78591	ISOPHORONE	0.00058	1.1-14
7439976	MERCURY	0.000083	1.1-18
CH4	METHANE	5	1.1-19
74839	METHYL BROMIDE	0.00016	1.1-14
74873	METHYL CHLORIDE	0.00053	1.1-14
80626	METHYL METHACRYLATE	0.00002	1.1-14
1634044	METHYL TERT BUTYL ETHER	0.000035	1.1-14
75092	METHYLENE CHLORIDE	0.00029	1.1-14
91203	NAPHTHALENE	0.000013	1.1-13
N2O	NITROUS OXIDE	0.04	1.1-19
85018	PHENANTHRENE	0.0000027	1.1-13
108952	PHENOL	0.000016	1.1-14

Pollutant Code	Pollutant Code Description	Emissions Factor (LB/TON)	Data Source, AP-42 [ref 4] Table No.
123386	PROPIONALDEHYDE	0.00038	1.1-14
129000	PYRENE	0.00000033	1.1-13
100425	STYRENE	0.000025	1.1-14
127184	TETRACHLOROETHYLENE	0.000043	1.1-14
108883	TOLUENE	0.00024	1.1-14
108054	VINYL ACETATE	0.0000076	1.1-14
1330207	XYLENES	0.000037	1.1-14
CO	CARBON MONOXIDE	275	1.1-3
NH3	AMMONIA	2	[ref **Error! Reference source not found.**]
NOX	NITROGEN OXIDES	9.1	1.1-3
PM10-FIL	PRIMARY PM_{10}, FILTERABLE PORTION	6.2	1.1-4
PM25-FIL	PRIMARY $PM_{2.5}$, FILTERABLE PORTION	3.8	1.1-11
PM-CON	PRIMARY PM CONDENSIBLE PORTION	1.04	1.1-5
PM10-PRI	PRIMARY PM_{10} (FILT + COND)	7.24	1.1-4, 1.1-5
PM25-PRI	PRIMARY $PM_{2.5}$ (FILT + COND)	4.84	1.1-5, 1.1-11
VOC	VOLATILE ORGANIC COMPOUNDS	10	1.1-19

For CO and VOC, the emission factors listed for anthracite coal are the emission factors provided in AP-42 for bituminous coal. Emission rates for these pollutants are dependent upon combustion efficiency, with the mass of emissions per unit of heat input generally increasing with decreasing unit size. No anthracite emission rates were provided for residential heaters for these pollutants. Therefore, it was felt that it the AP-42 emission rates from bituminous coal that were derived for smaller hand-fed units, were more appropriate to use than applying anthracite emission factors derived for much larger boilers.

Note that while AP-42 provides emission factors for some metals, these were based on tests at controlled and/or pulverized coal boilers. These are not expected to be a good representation of emission rates for metals from residential heaters, so these pollutants are not included.

The criteria pollutant and HAP emissions were calculated by multiplying the total coal consumed in each county per year by the corresponding emission factor.

<u>LPG</u>

Pollutant emission factors for residential LPG are based on the residential natural gas emission factors [ref 4, ref 6, ref 7]. For all counties in the United States, the natural gas consumed by residential combustion is assumed to have a heating value of 1,020 Btu per cubic foot and a sulfur content of 2,000 grains per million cubic feet [ref 4]. Those natural gas emission factors originally presented in the units “pounds per million cubic feet” were converted to energy-based units using the 1,020 Btu/cubic foot conversion factor. Once all the natural gas emission factors were converted to energy-based units, the natural gas emission factors were converted to LPG emission factors by multiplying by 96,750 Btu/gallon. Some emission factors were revised based on recommendations by an ERTAC advisory panel composed of state and EPA personnel. Table 4-80 provides a summary of the pollutants, pollutant codes, and emission factors for residential combustion of LPG.

Table 4-80: Residential LPG combustion emission factors

Pollutant Code	Pollutant Code Description	Emissions Factor (LB/E3BBL)
129000	Pyrene	2.09E-05
206440	Fluoranthene	1.26E-05
50000	Formaldehyde	3.14E-01
71432	Benzene	8.78E-03
75070	Acetaldehyde	5.44E-05
85018	Phenanthrene	7.11E-05
86737	Fluorene	1.17E-05
91203	Naphthalene	2.55E-03
CO	CO	1.60E+02
NH3	Ammonia	1.95E+00
NOX	NO_X	5.63E+02
PM10-PRI	PRIMARY PM_{10} (INCLUDES FILTERABLES + CONDENSIBLES)	2.07E+00
PM25-PRI	PRIMARY $PM_{2.5}$ (INCLUDES FILTERABLES + CONDENSIBLES)	1.71E+00
PM10-FIL	PRIMARY PM_{10}, FILTERABLE PORTION ONLY	7.97E-01
PM25-FIL	PRIMARY $PM_{2.5}$, FILTERABLE PORTION ONLY	4.38E-01
PM-CON	PRIMARY PM CONDENSIBLE PORTION ONLY (<1 MICRON)	1.28E+00
SO2	SO_2	2.39E+00
VOC	VOC	2.19E+01

4.13.3.4 *Example Calculations*

Natural Gas, Distillate, Kerosene, and LPG Equations

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

$$E_{x,p} = FC_x \times EF_{x,p}$$

where:

$E_{x,p}$ = annual emissions for fuel type x and pollutant p,
FC_x = annual fuel consumption for fuel type x,
$EF_{x,p}$ = emission factor for fuel type x and pollutant p,

And $FC_x = A_{State} \times (H_{county} / H_{State})$

where:

A_{State} = state activity data from EIA
H_{County} = number of houses in the county using the fuel type as the primary heating fuel. For distillate and kerosene, this is the sum of both fuels.
H_{State} = number of houses in the state using the fuel type as the primary heating fuel. For distillate and kerosene, this is the sum of both fuels.

Natural Gas Example

Using Allegheny County, PA as an example:

The State of Pennsylvania had a reported use of 254,816 million cubic feet of natural gas in the residential sector in 2014. Allegheny County, PA had 444,844 houses out of the state total of 2,529,063 that use natural gas as the primary heating fuel. This equates to a share of 17.59% of the natural gas used for residential heating in the state. From Table 4-73, the CO emission factor is 40 lb/million ft^3.

$$E_{CO} = 254{,}816 \text{ million ft}^3 \times (444{,}844 \text{ houses} / 2{,}529{,}063 \text{ houses}) \times 40 \text{ lb CO/ million ft}^3$$
$$= 1{,}792{,}812 \text{ lb CO or } 896.41 \text{ tons CO}$$

Distillate Oil Example

Using Allegheny County, PA as an example:

The State of Pennsylvania had a reported use of 15,798 thousand barrels of distillate oil and 358 barrels of kerosene in the residential sector in 2014. Allegheny County, PA had 8,081 houses that use distillate fuel oil or kerosene as the primary heating fuel. Using the state ratio of distillate to kerosene, Allegheny County can be assumed to have 7,902 houses using distillate as the primary heating fuel, out of 910,155 houses in the state. This equates to a share of 0.89% of the distillate oil used for residential heating in the state. From Table 4-74, the emission factor for CO is 5 lb/thousand gallons. Because the emission factor is in lbs/thousand gallons, a conversion factor of 42 gallons per barrel is applied.

$$A_{Alegheny} = 15{,}798 \text{ thousand barrels} \times 7{,}902 \text{ houses} / 910{,}155 \text{ houses}) \times 42 \text{ gal / barrel}$$
$$= 5{,}760.62 \text{ thousand gallons}$$
$$Emis_{Alegheny,\ CO} = 5{,}760.2 \text{ thousand gallons} \times 5 \text{ lb CO/ thousand gallons}$$
$$= 28{,}803 \text{ lbs CO or } 14.4 \text{ tons CO}$$

Kerosene Example

Using Allegheny County, PA as an example:

The State of Pennsylvania had a reported use of 15,798 thousand barrels of distillate oil and 358 thousand barrels of kerosene in the residential sector in 2014. Allegheny County, PA had 8,081 houses that use distillate fuel oil or kerosene as the primary heating fuel. Using the state ratio of distillate to kerosene, Allegheny County can be assumed to have 179.07 houses using kerosene as the primary heating fuel, out of 20,625 houses in the state. This equates to a share of 0.87% of the kerosene used for residential heating in the state. From Table 4-75, the CO Emission factor is 202.5 lb/thousand barrels. Because the emission factor is in lbs/thousand gallons, a conversion factor of 42 gallons per barrel is applied.

$$A_{Alegheny} = 358 \text{ thousand barrels} \times (179.07 \text{ houses} / 20{,}625 \text{ houses})$$
$$= 3.1 \text{ thousand gallons}$$
$$Emis_{Alegheny,\ CO} = 3.1 \text{ thousand gallons} \times 202.5 \text{ lb CO/ thousand gallons}$$
$$= 629.4 \text{ lbs CO or } 0.31 \text{ tons CO}$$

LPG Example

Using Allegheny County, PA as an example:

The State of Pennsylvania had a reported use of 4,909 thousand barrels of LPG in the residential sector in 2014. Allegheny County, PA had 4,460 houses out of the state total of 189,112 that use LPG as the primary heating fuel. This equates to a share of 2.36% of the LPG used for residential heating in the state. From Table 4-80, the CO emission factor is 159.6 lb/thousand barrels.

E_{CO} = 4,909 thousand barrels × (4,460 houses / 189,112 houses) × 159.6 lb/thousand barrels
= 18,480 lb CO or 9.24 tons CO

Coal Equations

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

$$E_{x,p} = FC_x \times (1 - CE_{x,p}) \times EF_{x,p}$$

where:

$E_{x,p}$ = annual emissions for fuel type x and pollutant p (lb/year),
FC_x = annual county-level fuel consumption for fuel type x,
$CE_{x,p}$ = control efficiency for fuel type x and pollutant p, and
$EF_{x,p}$ = emission factor for fuel type x and pollutant p.

County-level fuel consumption is calculated using:

$$FC_x = A_{State} \text{ x } Ratio_{Anth, Bit} \text{ x } Ratio_{County\ houses}$$

where:

A_{State} = total tons of coal reported by the EIA,
$Ratio_{Anth, Bit}$ = ratio reported in Table 4-72, and
$Ratio_{County\ houses}$ = county allocation ratio based on number of houses burning coal.

Coal Example

Using Allegheny County, PA as an example:

(numbers are from 2011 inventory, SEDS data showed no coal consumption in any state in 2014)

The State of Pennsylvania had a reported use of 20,121 tons of coal in the residential sector in 2010. Statewide anthracite coal use is calculated using the ratio of anthracite to bituminous in Table 4-72 for PA: 80.6%. Allegheny County, PA had 183 houses out of the state total of 67,986 that use coal as the primary heating fuel. This equates to a share of 0.27% of the coal used for residential heating in the state. Thus, the anthracite fuel consumption for Allegheny County is:

$FC_{Allegheny, anth}$ = 20,121 × 0.806 × 0.0027 = 44 tons anthracite coal

The $PM_{2.5}$-PRI emission factor for residential heating with anthracite coal is 4.6 + 0.08 lbs/ton× state-specific % ash content (see Table 4-77). The ash content is 13.38%, (see Section 4.13.3.3) so the emission factor is 5.67 lbs/ton.

$Emis_{Allegheny, anth, PM_{2.5-PRI}}$ = 44 tons anthracite coal × 5.67 lbs $PM_{2.5}$-PRI per ton coal
= 249 lbs $PM_{2.5}$-PRI

4.13.3.5 *Changes from 2011 and 2014v1 Methodology*

All fuels

Activity data were updated to 2013 SEDS for 2014v1 and 2014 SEDS for 2014v2, and allocated to counties using the US Census Bureau's 2013 (for 2014v1) and 2014 (for 2014v2) 5-year estimate Census Detailed Housing Information.

Distillate and Kerosene

In addition to the updated activity data, for distillate and kerosene, the more significant difference between 2011 and 2014 was the allocation of distillate oil consumption. The US Census Bureau Detailed Housing Information category for homes using distillate oil also includes kerosene as a fuel source. To tease apart the number of houses using each of these fuels, the number was multiplied by the ratio of state distillate or kerosene consumption to the total state consumption of distillate oil and kerosene. These steps were not taken in 2011.

4.13.3.6 *Puerto Rico and US Virgin Islands Emissions Calculations*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward County (FIPS state county code = 12011) for Puerto Rico and Monroe County (FIPS = 12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.13.4 References for fuel combustion -residential – natural gas, oil and other

1. U.S. Department of Energy, Energy Information Administration (EIA). State Energy Data System (SEDS): 1960-2014 Consumption. Washington, DC 2015, accessed July 2016.
2. U.S. Census Bureau. B25040 House Heating Fuel, 2009-2013 American Community Survey 5-Year Estimates, accessed July 2014.
3. EIA, 2008. U.S. Department of Energy, Energy Information Administration, Domestic Distribution of U.S. Coal by Destination State, Consumer, Origin and Method of Transportation, 2006, accessed September 2015.
4. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, 5th Edition, AP-42, Volume I: Stationary Point and Area Sources. Research Triangle Park, North Carolina. 1996.
5. Pechan, 2004: E.H. Pechan & Associates, Inc. Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources - Draft Final Report, prepared for the Emission Inventory Improvement Program, April 2004.
6. U.S. Environmental Protection Agency, Emission Factors and Inventory Group. "Documentation for the 1999 Base Year Nonpoint Area Source National Emission Inventory for Hazardous Air Pollutants." Prepared by Eastern Research Group, Inc. Morrisville, NC. September 2002.
7. U.S. Environmental Protection Agency. Emission Factor and Inventory Group. Final Summary of the Development and Results of a Methodology for Calculating Area Source Emissions from Residential Fuel Combustion. Prepared by Pacific Environmental Services, Inc. Research Triangle Park, NC. September 2002, accessed September 2015.
8. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. "Documentation of Emissions Estimation methods for Year 2000 and 2001 Mobile Source and Nonpoint Source Dioxin Inventories." Prepared by E.H. Pechan & Associates, Inc., Durham, NC. May 2003.

4.14 Fuel Combustion – Residential – Wood

4.14.1 Sector Description

This source category includes residential wood burning devices such as fireplaces, fireplaces with inserts (inserts), free standing woodstoves, pellet stoves, outdoor hydronic heaters (also known as outdoor wood boilers), indoor furnaces, and outdoor burning in firepits and chimeneas. We further differentiate free standing woodstoves and inserts into three categories: conventional (not EPA certified); EPA certified, catalytic; and EPA certified, noncatalytic. Generally, the conventional units were constructed prior to 1988. Units constructed after 1988 had to meet EPA emission standards and they are either catalytic or non-catalytic. For shorthand, we refer to the Residential Wood Combustion sector as “RWC” in the remaining documentation.

Table 4-81 shows the SCCs used in the 2014 NEI from in this sector. EPA estimates emissions for all SCCs in this sector. The SCC level 1 and 2 descriptions is “Stationary Source Fuel Combustion; Residential” for all SCCs.

Table 4-81: RWC sector SCCs in the 2014 NEI

SCC	SCC Level Three*	SCC Level Four
2104008100	Wood	Fireplace: general
2104008210	Wood	Woodstove: fireplace inserts; non-EPA certified
2104008220	Wood	Woodstove: fireplace inserts; EPA certified; non-catalytic
2104008230	Wood	Woodstove: fireplace inserts; EPA certified; catalytic
2104008310	Wood	Woodstove: freestanding, non-EPA certified
2104008320	Wood	Woodstove: freestanding, EPA certified, non-catalytic
2104008330	Wood	Woodstove: freestanding, EPA certified, catalytic
2104008400	Wood	Woodstove: pellet-fired, general (freestanding or FP insert)
2104008510	Wood	Furnace: Indoor, cordwood-fired, non-EPA certified
2104008610	Wood	Hydronic heater: outdoor (“outdoor wood boilers”)
2104008700	Wood	Outdoor wood burning device, NEC (fire-pits, chimeneas, etc)
2104009000	Firelog	Total: All Combustor Types

4.14.2 Sources of data

The RWC sector includes emissions from both S/L/T agencies and from the EPA. As is the case with most nonpoint sources, RWC data submitted by S/L/Ts is used over EPA data when provided. The EPA worked with S/L/Ts to modify the RWC Tool for the 2014 NEI. While many reporting agencies were involved in discussions on the development of the EPA’s RWC Tool used for the 2014 NEI, many opted to run the tool with their own customized inputs and assumptions, or decided to submit their own estimates developed outside the RWC Tool.

The agencies listed in Table 4-82 submitted at least $PM_{2.5}$ and/or VOC emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-82: Reporting agency $PM_{2.5}$ and VOC percent contribution to total NEI emissions for RWC sector

Region	Agency	S/L/T	$PM_{2.5}$	VOC
1	Vermont Department of Environmental Conservation	State	100	100
3	Delaware Department of Natural Resources and Environmental Control	State	100	100
4	Metro Public Health of Nashville/Davidson County	Local		84
5	Illinois Environmental Protection Agency	State	100	100

Region	Agency	S/L/T	$PM_{2.5}$	VOC
5	Michigan Department of Environmental Quality	State	100	100
5	Minnesota Pollution Control Agency	State	99	100
6	Louisiana Department of Environmental Quality	State	96	99
6	Texas Commission on Environmental Quality	State	100	100
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	100	100
8	Northern Cheyenne Tribe	Tribe	100	100
9	Arizona Department of Environmental Quality	State	100	100
9	California Air Resources Board	State	100	100
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	Tribe	100	100
9	Washoe County Health District	Local	91	97
10	Coeur d'Alene Tribe	Tribe	100	100
10	Kootenai Tribe of Idaho	Tribe	100	100
10	Nez Perce Tribe	Tribe	100	100
10	Oregon Department of Environmental Quality	State	94	95
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100	100
10	Washington State Department of Ecology	State	96	97

4.14.3 EPA-developed emissions for residential wood combustion: minor revisions for 2014v2 NEI

The EPA collaborated with State, Local and Regional Planning Organization representatives to create a new methodology for the RWC Tool for 2014v1 NEI. Some minor updates were included after v3.0 for Version 3.2 of the RWC Tool used for the 2014v2 NEI. The changes to the EPA methodology between 2014v1 NEI (v3.0 of the RWC tool) and the 2014v2 NEI (v3.2) are highlighted in following sections where they apply.

The RWC Tool is designed to allow users the ability to apply county-specific inputs on various types of activity data including appliance fractions, burn rates, certification profiles and burn ban assumptions. We also allowed for state-to-county allocations of outdoor wood boilers and indoor furnaces to be computed by inverse population density rather than the default rural population; however, after comparing county allocations between the two methods, very few stakeholders saw the inverse population density option as a better option.

Emissions in the RWC Tool are computed using the equation here:

$$\text{Emissions} = \text{Homes} \times \text{ApplianceFrac} \times \text{BurnRate} \times \text{WoodDensity} \times \text{AdjustFactor} \times \text{EF}$$

where,

Emissions	= annual emissions (ton/year) for a specific appliance (SCC), county and pollutant
Homes	= number of occupied homes in each county,
ApplianceFrac	= fraction of homes in each county that use the appliance,
BurnRate	= average amount of wood burned per appliance (cords/appliance),
WoodDensity	= density of firewood (tons/cord),
AdjustFactor	= county and SCC-specific adjustment factor to account for burn bans,
EF	= emission factor (tons of pollutant emitted/ton of fuel used)

There is a specific approach for different appliance types (SCCs) for each of the terms in the above equation. The activity data for RWC is the total amount of wood burned. It is estimated by multiplying the number of occupied homes in each county by the appliance fraction to estimate the number of appliances operated annually in the county. This number is multiplied by the burn rate to estimate the total amount of wood burned in each appliance in each county.

4.14.3.1 *Occupied Homes in each County*

Because appliance fractions are estimated in terms of the fraction of occupied units by appliance type, it is important that county population also be based on the number of occupied units. The number of occupied housing units is derived from the U.S. Census Bureau 2014 American Community Survey [ref 1], which reports on the number of homes by the type of house:

- Single-family detached homes,
- Single-family attached homes,
- Multi-family homes with 2-4 units,
- Multi-family homes with more than 5 units, and
- Mobile homes, boats, recreational vehicles, vans, etc.

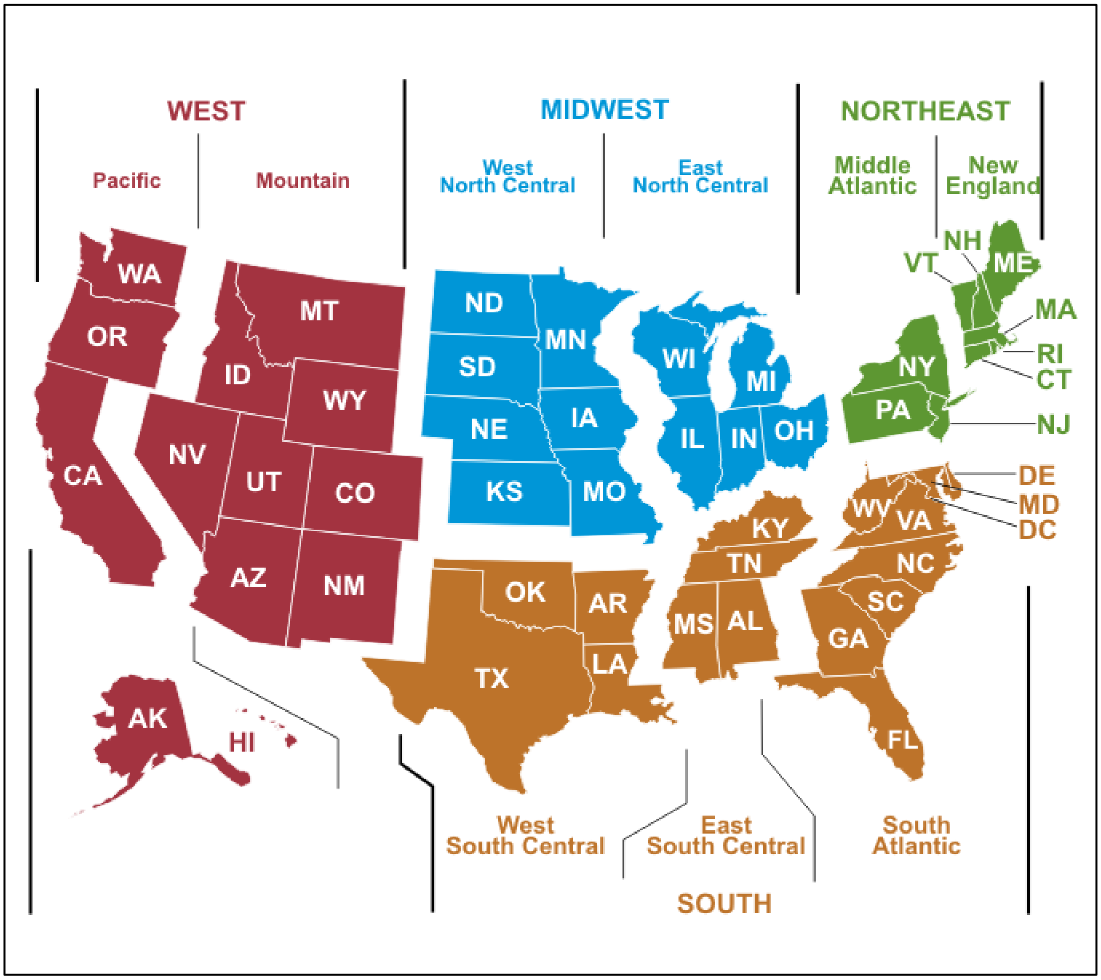
Each of these home types is further divided into urban and rural homes; for example, the number of urban single-family detached homes, the number of rural single-family detached homes, and so on. Using the proportion of total urban and rural homes in each county from the 2010 U.S. Census [ref 2], the RWC Tool therefore computes up to 10 different classes occupied housing units per county.

4.14.3.2 *Appliance fractions: updated for 2014v2 NEI*

Appliance fractions are the fraction of occupied homes in each county that uses each type of wood burning appliance. These appliance fractions are mapped to the 10 different types of occupied homes in each county. The appliance fractions are calculated using two main data sources: The Energy Information Administration (EIA) year-2009 "RECS" Residential Energy Combustion Survey [ref 3] and the 2013 American Housing Survey (AHS) [ref 4]. It is important to note that the most recent RECS data is for year 2009. As of May 2017, year 2013 RECS data, likely more-aligned with year 2014 wood usage, is not yet available. Year 2014 AHS data was not made available until after the development of this RWC Tool in the spring of 2017. Both the RECS and AHS includes survey data that asks respondents whether they use a given wood burning appliance.

The RECS data includes a nationally representative sample of wood burning characteristics for each type of housing unit. The 2009 RECS is based on 12,083 households used to represent the 113.6 million occupied homes. The RECS provides information on the average wood consumption used as primary and secondary heating by each of the 4 U.S. Census Regions –see Figure 4-9. The AHS data includes information on wood usage for each U.S. Census Division by type of wood burning device: Stoves, Fireplaces with inserts, and fireplaces without inserts. The AHS data also delineates between various population density characteristics within each Census Division: central city of metro area, outside central city but within metro area, and outside the metro area.

Figure 4-9: U.S. Census Regions and Census Divisions



<u>Fireplaces, Woodstoves, and Indoor Furnaces</u>

The methodology for estimating the appliance fraction from fireplaces, fireplace inserts, freestanding woodstoves, pellet stoves, and indoor furnaces uses the EIA's RECS microdata, which consists of 27,187 individual survey responses between 1997 and 2009. RECS asks a wide variety of questions related to home energy use, including several that are important for RWC emissions estimation:

- The appliance used for the main heat source in the home,
- The fuel used for the main heat source in the home,
- Whether the home uses a woodstove for a secondary heat source,
- Whether the home uses a fireplace for a secondary heat source.
- The amount of wood burned (cords) annually by the home.

The RECS data also includes demographic data about the respondent, including their census division location, the number of heating degree days in their area, the type of house they live in, and whether their home is in an urban or rural setting.

The appliance fractions were estimated using a regression technique called logistic regression that estimates the likelihood of a binary (i.e. yes or no) outcome. In this case the outcome is whether or not the home uses the wood burning appliance. The result of the logistic regression analysis is an equation that uses the demographic variables to predict the proportion of homes in each county that uses each appliance:

$$\hat{p} = \frac{1}{1 + e^{-(\beta_0 + \beta_1 \cdot HDD + \beta_2 \cdot HomeType + \beta_3 \cdot UrbanRural + \beta_4 \cdot ApplType + \beta_5 \cdot BurnType)}}$$

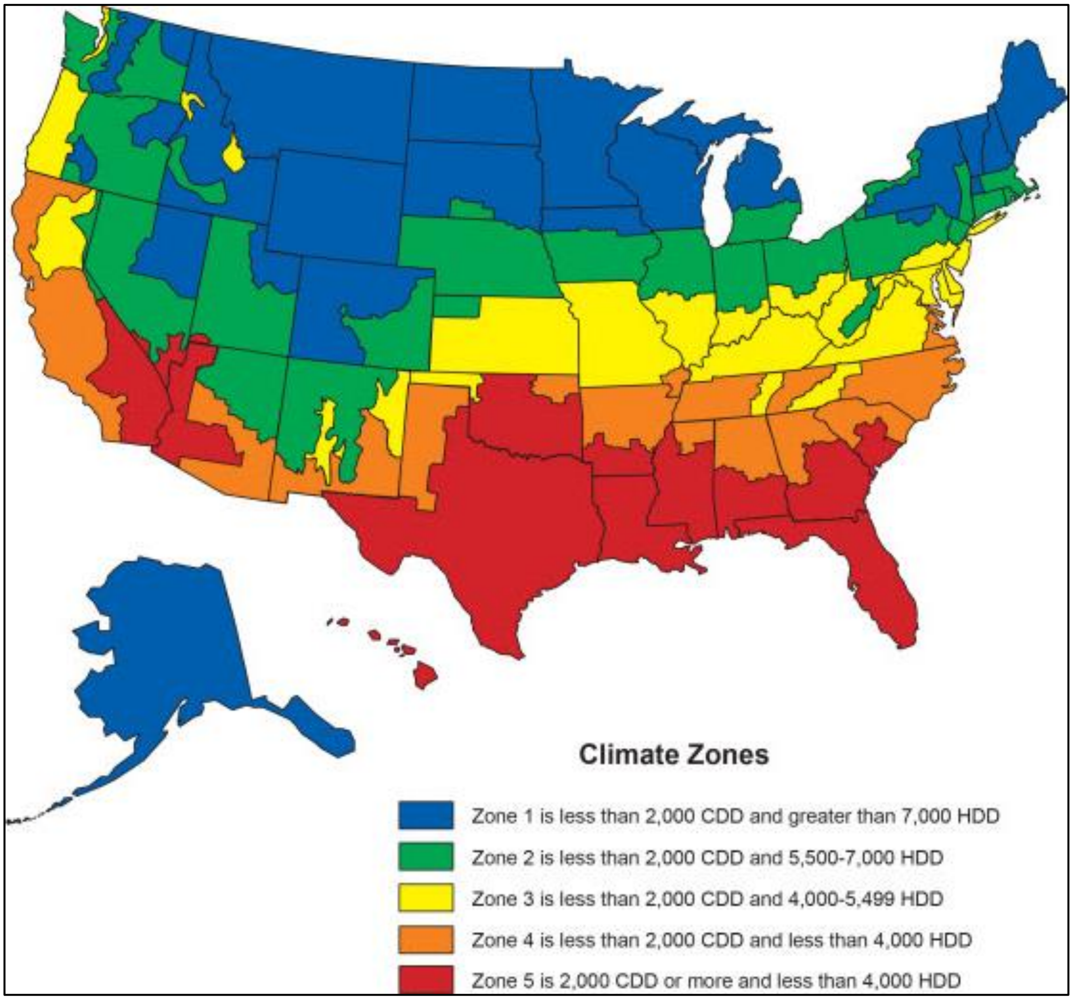
where:

- *p* = the probability that a home in a given county uses a given wood burning appliance
- HDD = the number of heating degree days in each county from NOAA [ref 5]
- HomeType = the type of home (5 types: single-family detached, single-family attached, multifamily with 2-4 units, multifamily with 5+ units, and mobile homes),
- UrbanRural = whether the home is in an urban or rural setting,
- ApplType = appliance type (fireplaces, woodstoves, and furnaces), and
- BurnTypes = whether the appliance is used for primary/main heat or other heating (only main heating was used for furnaces)

The logistic regression analysis estimates the coefficients (β_i) used in the equation. When those coefficients are used with the predictor variables listed above, the equation estimates the probability that a home uses a wood burning appliance.

An example of the distribution of heating degree days is shown in Figure 4-10. We include heating degree days in the logistic regression equation to refine the spatial allocation within the large Census Regions. For example, we would not expect primary heating from woodstoves to be similar between West Virginia and Florida –both states are in the South Census Region. Alternatively, for most regions, there did not appear to be enough survey responses to allocate appliances to more fine-scale Census Division.

Figure 4-10: AIA climate zones from the 1978-2005 RECS



The result of the logistic regression analysis is 40 unique appliance fractions for each county. These appliance fractions are multiplied by the number of homes in each county in each category. For example, the appliance fraction for main heating by woodstoves in urban mobile homes is multiplied by the number of urban mobile homes in each county to determine the total number of woodstoves that were used for main heating in urban mobile homes. This process is repeated for all home types, appliance types, and burn types.

New for the 2014v2 NEI (RWC Tool V3.2), for fireplaces, the appliance fractions are also adjusted to account for the fraction of fireplaces that burn natural gas or propane rather than wood. Data from RECS suggests that approximately 49 percent of fireplaces in urban homes and 47 percent of fireplaces in rural homes burn wood. The default assumption of the RWC tool is that all woodstoves are 100 percent wood burning.

Certification Profiles

Because the data from EIA's RECS does not specify whether the respondent uses a woodstove or fireplace insert that is certified, the general data on the number of woodstoves and fireplaces must be split into specific SCCs based on assumptions. In the RWC tool, we developed "certification profiles" that are grouped by Appliance Type (woodstove or fireplace) and Census Region.

The certification profile assumptions can be adjusted in the tool, but the profile ratios when grouped by appliance type and region should sum to 1. For example, the sum of the profile ratios for woodstoves in the Midwest Census Region should equal 1.

Table 4-83 shows the certification profiles for woodstoves, which are used to split the general data on woodstove populations into four SCCs: freestanding non-EPA certified stoves, freestanding EPA certified non-catalytic stoves, freestanding EPA certified catalytic stoves, and pellet stoves. RECS data is used to estimate these certification profiles. Although RECS does not specifically ask whether the woodstove is EPA certified, the 2009 edition does ask the age of the appliance. It is assumed that any appliance older than 20 years old is uncertified, since the appliance would have been built prior to the first New Source Performance Standard (NSPS) for woodstoves, finalized in 1988. All appliances less than 20 years old are assumed to be EPA certified. The certification profile for pellet stoves is based on the proportion of respondents to RECS that use a woodstove but their main fuel source is wood pellets, rather than cordwood. Reporting agencies have the ability to modify these profiles by appliance type to the county-level, but for EPA estimates, a national default is used. Once the RECS data is used to determine the proportion of stoves that are certified vs. noncertified, data provided by Minnesota from their 2014/2015 residential wood survey is used to determine the proportion of certified stoves that are noncatalytic vs. catalytic. There was not enough information in the RECs data to refine the certification profiles by geographic region; therefore, these profiles are the same nationally for all types of woodstoves.

Table 4-83: Certification profiles for woodstoves

SCC	Description	Northeast	Midwest	South	West
2104008310	Woodstove: freestanding, non-EPA certified	0.286	0.286	0.286	0.286
2104008320	Woodstove: freestanding, EPA certified, non-catalytic	0.355	0.355	0.355	0.355
2104008330	Woodstove: freestanding, EPA certified, catalytic	0.237	0.237	0.237	0.237
2104008400	Woodstove: pellet-fired, general	0.122	0.122	0.122	0.122
	Total	**1**	**1**	**1**	**1**

Table 4-84 shows the certification profiles for fireplaces, which are used to split the general data on fireplace populations into four SCCs: general fireplaces, non-EPA certified fireplace inserts, EPA certified non-catalytic inserts, and EPA certified catalytic inserts. The AHS asks respondents whether their fireplace has an insert, and reports these data at the census region level. The split between certified and non-certified, and catalytic and non-catalytic inserts are based on data provided by Minnesota from their 2014/2015 residential wood survey.

Table 4-84: Certification profiles for fireplaces

SCC	Description	Northeast	Midwest	South	West
2104008110	Fireplace: general	0.487	0.438	0.575	0.523
2104008210	Woodstove: fireplace inserts, non-EPA certified	0.278	0.305	0.23	0.258
2104008220	Woodstove: fireplace inserts, EPA certified, non-catalytic	0.182	0.199	0.151	0.169
2104008230	Woodstove: fireplace inserts, EPA certified, catalytic	0.053	0.058	0.044	0.050
	Total	**1**	**1**	**1**	**1**

Outdoor Hydronic Heaters (OHHs)

For OHHs (outdoor wood boilers), a different approach is used to determine the number of appliances in use. There are not enough survey responses to RECS by respondents that use OHHs to allow for the type of regression analysis used for the other appliance types. Therefore, the appliance fractions for OHHs are calculated using data from the American Housing Survey. In 2011 (the only year in which this question was included in the AHS), the AHS asked whether the respondent used an OHH. Like the RECS data, the AHS include demographic data about the respondent, including their census region and division location, and climate zone, which is defined by number of heating degree days.

The total number of estimated OHHs are divided into each unique combination of census region and climate zone. This total OHHs population is then distributed to each county within the unique census region and climate zone based on proportion of rural population. For example, there are estimated to be approximately 15,000 OHHs in the coldest climate zone of the Northeast census region, which includes 100 counties. These 15,000 OHHs are distributed to the counties with the highest proportion of rural population.

There are two exceptions to this methodology. The first is that for the West census region, the OHH population is apportioned based on unique combinations of census division (rather than census region) and climate zone. In the west, OHH sales and usage are under significantly more scrutiny in the Pacific census division compared to the mountain census division; it therefore does not make sense to treat appliance profiles the same in the entire region. The second is that there were some states, specifically, Michigan, Ohio, and Wisconsin that (initially) preferred to distribute the OHHs based on inverse population density rather than rural population. In this way, most of the OHHs are distributed to the least dense (people/mi_2) counties. The RWC tool offers the capability in the "Edit Assumptions" window to redistribute the emissions from OHHs and furnaces based on inverse population density rather than rural population. On further inspection of the OHH emissions resulting from this method, one of these Midwest states opted to resubmit RWC emissions. In short, we advise to use caution if considering using the inverse population method.

The appliance fractions for OHHs are estimated by dividing the number of OHHs distributed to each county by the number of occupied houses in each county in 2011. This number is then multiplied by the number of occupied houses in 2014 to estimate the county-level OHH population in 2014.

Wax Firelogs and Other Outdoor Wood Burning Devices

Data were unavailable to update the activity data for wax firelogs and outdoor wood burning devices (e.g. firepits or chimeneas). The activity data for these source categories is pulled forward from the 2011 NEI methodology, which is based mostly on AHS data, though for firelogs, includes a 30% downward adjustment to account for natural gas usage (Houck, 2003).

4.14.3.3 *Burn rates: additional user option for 2014v2 NEI*

Burn rates are the amount of wood burned annually for each appliance, reflected in cords for all appliance types except for firelogs, which are expressed as tons. The burn rates for fireplaces, woodstoves and indoor furnaces are estimated from the same 2009 RECS data used to create the appliance fractions.

Similar to the methodology for estimating the appliance fractions, the burn rates are estimated using regression analysis based on each unique combination of home type, urban or rural setting, appliance type, and burn type. The results of the regression analysis show that the number of heating degree days is not a significant predictor variable for most of the United States, and therefore it is not included in the analysis for all census regions, except for the South Atlantic division within the South region. The South Atlantic division –spanning disparate climates from West Virginia to Florida- therefore includes heating degree days for allocation. The rest of the South region –east south central and west south central- uses a "rest-of South region" allocation that does not include heating degree days in its allocation.

The burn rates match the level of specificity of the appliance fractions. For example, there are unique burn rates and appliance fractions for each county for rural mobile homes that use fireplaces as a secondary heat source, as well as all other combinations of home type, appliance type, and burn type.

The AHS data used to estimate the appliance fractions for OHHs does not include data on the amount of wood burned. Therefore, the burn rates for OHHs are pulled forward from the 2011 methodology, which is based largely on expert judgment. Burn rates were zeroed out for all counties with greater than 1,500 housing units per square mile. Additional burn rate information from state or local surveys was carried over from the 2011 methodology for California, Oregon, Washington, Minnesota and Vermont. Otherwise, the general approach uses expert judgment to estimate burn rates for OHHs and scales them based on climate zone.

Similarly, the burn rates for wax firelogs and outdoor wood burning devices are pulled forward from the 2011 NEI methodology, which is also based mostly on expert judgment.

New to the RWC Tool v3.2 (2014v2 NEI), users were allowed to provide county and appliance-specific burn rates to override the RECS-based (EPA) defaults in the tool

4.14.3.4 *Wood density*

The density of oven dried wood is used to compute average density of wood by county because emission factors developed by EPA are based on oven dried wood mass units. Dried wood density data are obtained from the U.S. Forest Service (USDA, 2007) [ref 6] for various wood species. The Forest Service developed a database (called the Timber Products Output) that contains survey results of sawmill operators that includes the volume of wood by species for several different categories of use - one of the uses being fuel wood.

Using the oven dried density by species multiplied by the per-species volumes gives a per species weight which is summed to calculate the total weight for the county. This is then divided by the total volume of wood in the county to get the average density by county. If a county specific density is not available, regional averages are used instead.

The calculated density by county from the Forest Service data is then converted to tons/cords. Officially a cord is defined as a stack of wood 4 feet wide, 8 feet long, and 4 feet tall or 128 cubic feet. However, we instead assume a value of 80 cubic feet per cord to account for air spaces in the stack.

For wax firelogs, density is assumed to not vary from county to county, and a density of 4.005 tons per cord is used. This is based on the volume of a typical 5 pound firelog. For wax firelogs, a cord is assumed to be 128 ft_3 because air spaces assumptions are not applicable.

4.14.3.5 *Emission factors: updated for 2014v2 NEI*

The emission factors in the RWC Tool are expressed as tons of pollutant produced for every ton of wood burned. The emission factors were last reviewed for the 2011 NEI by the Eastern Regional Technical Advisory Committee (ERTAC). The complete list of emission factors and their references are available in the RWC Tool and RWC Tool V3.0 PDF documentation available on the 2014v1 Supplemental Data FTP site.

Many of the emission factors used to determine national emission estimates for RWC are from EPA's AP-42 document (Tables 1.9-1, 1.10-3, and 1.10-4). Some of the stove and insert factors were adjusted based on new data developed in the reference *Review of Wood Heater and Fireplace Emission Factors* (Houck et al. 2001) [ref 7]. The emission factors generated by Houck, et. al. for 7-PAH and 16-PAH are lower than the associated AP-42 emission factors. Therefore, the AP-42 PAH emission factors were adjusted downward by 62% for conventional woodstoves, 51% for catalytic woodstoves, and 40% for non-catalytic woodstoves.

Version 3.2 of the RWC Tool, used for the 2014v2 NEI, changes were made to all emission factors for EPA-certified non-catalytic and catalytic wood stoves and fireplace inserts to account for an increase in appliances that meet emissions standards from EPA and Washington state.

As seen in Table 4-85, the particulate matter (PM_{10}) emission factors used for the 2014v1 NEI, the RWC Tool v3.0, are based on an average of the Phase I and Phase II emission factors from the 1988 New Source Performance Standards (NSPS) included in AP-42. While EPA did not update the federal NSPS until 2015, the Regulatory Impact Analysis (RIA) for the 2015 NSPS [ref 8] notes that the state of Washington introduced more stringent emissions standards for woodstoves in 1995. These standards result in approximately 40 percent less emissions than the Phase II EPA NSPS.

Table 4-85: PM_{10} woodstove standards and emission factors (lb/ton)

Standard	Source	Years	Catalytic	Non-catalytic
1988 NSPS Phase I	AP-42	1988-1990	19.6	20.0
1988 NSPS Phase II	AP-42	1990-1995	16.2	14.6
Washington Standards	2015 NSPS	1995-2015	9.72	8.76

When EPA calculated the baseline residential wood combustion emissions for the 2015 NSPS RIA, they assumed that shipments of woodstoves after 1995 would meet the more stringent Washington state standards. Because the EPA-certified non-catalytic and catalytic SCCs include many stoves of various ages that meet different standards, we crafted a methodology to estimate the number of woodstoves that fall under each of the standards. This enabled the creation of a weighted-average emission factor for certified woodstoves.

EIA's RECS contains data on energy use in homes, including the age of heating devices (including woodstoves) used in homes in the United States. RECS data are available for the years 1997, 2001, 2005, and 2009. We then used the RECS data to determine the proportion of stoves in each data year that fall under each standard, and then, projected the data to determine the proportion of stoves in 2014 that would meet each standard. As seen in Table 4-86, we then used this proportion to determine a weighted average emission factor for PM_{10} and CO for use in the new RWC Tool (v3.2) for the 2014v2 NEI.

Table 4-86: 2014v1 and 2014v2 NEI emission factors (lb/ton) for PM_{10} and CO

	2014v1 NEI Factors		**2014v2 NEI Factors**	
	PM_{10}	**CO**	**PM_{10}**	**CO**
Catalytic	20.4	104.4	15.2	92.3
Non-catalytic	19.6	140.8	14.5	122.6

For the different wood stove emissions standards, AP-42 only provides different emission factors for PM_{10} and CO. For all other pollutants, including HAPs, we can adjust the emission factors based on the percent decrease in the PM_{10} emission factor, which is 25% for catalytic and 26% for non-catalytic stoves.

The emissions factor for mercury was taken from AP-42, Chapter 1.6 Wood Residue Combustion in Boilers. The original emission factor of 3.50E-06 lbs. Hg/MMBtu was converted to a factor of 4.26E-05 lbs. Hg/ton of wood using a heating value of 15.3 MMBtu/cord from the U.S. Forest Service [ref 6] and an average density from the RWC Tool of 1.26 tons per cord.

4.14.3.6 *Other inputs: Appliance and Burn Ban Assumptions*

The RWC tool also allows users to make county and SCC-specific adjustments to account for appliance or burn bans. Users can update the inputs with additional SCCs and counties where the emissions should be adjusted. The calculated throughput and emissions for that SCC and county will be multiplied by the user-specified "Adjustment Factor". If, for example, a county has banned OHHs, then add the county FIPS code and the correct SCC (2104008610 for OHHs), and set the adjustment factor to 0. This will zero out the throughput and emissions for OHHs in that county.

Similarly, if a county has instituted a burn ban that is expected to reduce burning by 50%, the adjustment factor could be set to 0.5. This would reduce the calculated throughput and emissions for the listed SCC by 50%. To-date, EPA includes only OHH and indoor furnace zero outs for southern New York, provided by the NY State Department of Environmental Conservation.

4.14.4 Issues for 2017 NEI consideration

There are many known issues in the RWC Tool used for the 2014v2 NEI. Resources will determine how much can be included in the next version of the RWC Tool. Some known issues are lack of survey data in most areas. Having local appliance profiles and burn rate information is a high priority.

<u>Firelogs and Other outdoor equipment</u>

These "recreational RWC" estimates are carried forward from the 2011v2 NEI. We have not been able to find more updated information on these sources. Discussions with reporting agencies indicate that these emissions, particularly for other outdoor equipment like fire pits and chimeneas, vary greatly by geography from north to south.

<u>Outdoor Hydronic Heaters</u>

Burn rates information for OHHs is generally lacking in RECS and AHS data and in most available surveys. This is an ongoing area of need.

<u>Emission Factors</u>

Emission factors needs longer-term additional work for all appliance types. There are questions about unexpected factors when comparing non-catalytic to catalytic stoves, VOC HAPs to VOC factors, and how single burn-rate devices –not subject to the 1998 NSPS- are accounted for in the appliance profiles. Many emission factors rely on AP-42 factors, ERTAC studies, or worse, an inconsistent blend between multiple sources for the same appliance type.

<u>Land Use Data</u>

We would like to pursue a longer-term effort to analyze the impact of land cover to better-apportion emissions intra-Census Division or Region and climate zone; intuitively, in the absence of robust survey local data, we would expect less wood burning in areas with less available wood.

<u>Lack of local survey data for appliance profiles and burn rates</u>

There is very little local survey data included in the appliance profiles and burn rate calculations. A fledgling RWC Survey, targeting over 75,000 households over 15 states in different geographic regions, will be conducted in the spring and summer of 2018. Analysis on the survey results later in 2018 should hopefully improve the local activity data in these states and hopefully other nearby states with similar RWC consumption characteristics.

Inverse Population Allocation Option

The inverse population density approach redistributes the number of estimated OHHs and indoor furnaces within a state so that areas with the lowest population density get the highest number of appliances. There are currently only three states that use this approach: Michigan, Ohio, and Wisconsin. However, feedback from these states suggests that this approach results in too many emissions in some very rural counties. In the next version of the tool, we will attempt to limit the redistribution of appliances so that no county is estimated to have more than 10 percent of its homes with an OHH or indoor furnace.

4.14.5 References for residential wood combustion

1. U.S. Census Bureau. 2016a. American Community Survey, accessed April 2016.
2. U.S. Census Bureau. 2010 Census data.
3. Energy Information Administration (EIA). 2016. Residential Energy Consumption Survey (RECS), accessed April 2016.
4. U.S. Census Bureau. 2016b. American Housing Survey, accessed April 2016.
5. National Oceanic and Atmospheric Administration (NOAA). 2016. Degree Day Statistics, accessed April 2016.
6. U.S. Department of Agriculture (USDA). 2007. Timber Products Output Survey, Forestry Service, retrieved via query November 2007.
7. Houck, J., Crouch, J., Huntley, R., Review of Wood Heater and Fireplace Emission Factors, 10th International Emission Inventory Conference – "One Atmosphere, One Inventory, Many Challenges", Denver, CO, May 1 -3, 2001.
8. U.S. EPA. 2015. Regulatory Impact Analysis for Residential Wood Heaters NSPS Revision. EPA-452/R-15-001.

4.15 Industrial Processes – Mining and Quarrying

4.15.1 Sector description

Mining and quarrying activities produce particulate emissions due to the variety of processes used to extract the ore and associated overburden, including drilling and blasting, loading and unloading, and overburden replacement. Fugitive dust emissions for mining and quarrying operations are the sum of emissions from the mining of metallic and nonmetallic ores and coal. Each of these mining operations has specific emission factors accounting for the different means by which the resources are extracted.

The 2014 NEI has emissions for the two SCCs shown in Table 4-87 for this sector. The leading SCC description is "Industrial Processes; Mining and Quarrying: for all SCCs in the table. The EPA-estimated emissions cover only the "All Processes" SCC 2325000000. Emissions for "Lead Ore-Mining and Milling" SCC were submitted by Missouri.

Table 4-87: SCCs for Industrial Processes- Mining and Quarrying

SCC	Description
2325000000	All Processes; Total
2325060000	Lead Ore Mining and Milling; Total

4.15.2 Source of data

The mining and quarrying sector includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-88 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-88: Percentage of Mining and Quarrying $PM_{2.5}$ and PM_{10} emissions submitted by reporting agency

Region	Agency	PM_{10}	$PM_{2.5}$
2	New Jersey Department of Environment Protection	100	100
3	Maryland Department of the Environment	99	99
4	Knox County Department of Air Quality Management	100	100
7	Missouri Department of Natural Resources	60	75
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	100	100
8	Utah Division of Air Quality	100	100
9	Clark County Department of Air Quality and Environmental Management	100	100
9	Washoe County Health District	100	100
10	Alaska Department of Environmental Conservation	7	
10	Coeur d'Alene Tribe	100	100
10	Idaho Department of Environmental Quality	100	100
10	Nez Perce Tribe	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	100	100

4.15.3 EPA-developed emissions for mining and quarrying

The below sections explain how the PM_{10} and $PM_{2.5}$ emissions for the EPA data (SCC 2325000000; Industrial Processes; Mining and Quarrying: SIC 14; All Processes; Total) were developed.

4.15.3.1 *Emission Factors*

Metallic Ore Mining

The emissions factor for metallic ore mining includes overburden removal, drilling and blasting, and loading and unloading activities. The total suspended particulate (TSP) emission factors developed for copper ore mining are applied to all three activities with PM_{10}/TSP ratios of 0.35 for overburden removal, 0.81 for drilling and blasting, and 0.43 for loading and unloading operations [ref 1]. The emissions factor equation for metallic ore mining is:

$$EF_{mo} = EF_o + (B \times EF_b) + EF_l + EF_d$$

where,

EF_{mo} = metallic ore mining emissions factor (lbs/ton)
EF_o = PM_{10} open pit overburden removal emission factor for copper ore (lbs/ton)
B = fraction of total ore production that is obtained by blasting at metallic ore mines
EF_b = PM_{10} drilling/blasting emission factor for copper ore (lbs/ton)
EF_l = PM_{10} loading emission factor for copper ore (lbs/ton)
EF_d = PM_{10} truck dumping emission factor for copper ore (lbs/ton)

Applying the copper ore mining TSP emission factors [ref 2] and PM_{10}/TSP ratios yields the following metallic ore mining emissions factor:

EF_{mo} = 0.0003 + (0.57625 x 0.0008) + 0.022 + 0.032 = 0.0548 lbs/ton

Non-Metallic Ore Mining

The emissions factor for non-metallic ore mining includes overburden removal, drilling and blasting, and loading and unloading activities. The emissions factor is based on western surface coal mining operations.

EF_{nmo} = EFv + (D x EF_r) + EF_a + 0.5 (EF_e + EF_t)

where,

EF_{nmo} = non-metallic ore mining emissions factor (lbs/ton)
EF_v = PM_{10} open pit overburden removal emission factor at western surface coal mining operations (lbs/ton)
D = fraction of total ore production that is obtained by blasting at non-metallic ore mines
EF_r = PM_{10} drilling/blasting emission factor at western surface coal mining operations (lbs/ton)
EF_a = PM_{10} loading emission factor at western surface coal mining operations (lbs/ton)
EF_e = PM_{10} truck unloading: end dump-coal emission factor at western surface coal mining operations (lbs/ton)
EF_t = PM_{10} truck unloading: bottom dump-coal emission factor at western surface coal mining operations (lbs/ton)

Applying the TSP emission factors developed for western surface coal mining operations from AP-42 [ref 3] and a PM_{10}/TSP ratio of 0.4 [ref 4] yields the following non-metallic ore mining emissions factor:

EF_{nmo} = 0.225 + (0.61542 x 0.00005) + 0.05 + 0.5 (0.0035 + 0.033) = 0.293 lbs/ton

Coal Mining

The emissions factor for coal mining includes overburden removal, drilling and blasting, loading and unloading and overburden replacement activities. The amount of overburden material handled is assumed to equal ten times the quantity of coal mined and coal unloading is assumed to split evenly between end-dump and bottom-dump operations. The emissions factor equation for coal mining is:

EF_c = (10 × (EF_{to} + EF_{or} + EF_{dt})) + EF_v + EF_r +EF_a + (0.5 × (EF_e + EF_t))

where,

EF_c = coal mining emissions factor (lbs/ton)
EF_{to} =PM_{10} emission factor for truck loading overburden at western surface coal mining operations (lbs/ton of overburden)
EF_{or} = PM_{10} emission factor for overburden replacement at western surface coal mining operations (lbs/ton of overburden)
EF_{dt} = PM_{10} emission factors for truck unloading: bottom dump-overburden at western surface coal mining operations (lbs/ton of overburden)
EF_v = PM_{10} open pit overburden removal emission factor at western surface coal mining operations (lbs/ton)
EF_r = PM_{10} drilling/blasting emission factor at western surface coal mining operations (lbs/ton)

EF_a = PM_{10} loading emission factor at western surface coal mining operations (lbs/ton)
EF_e = PM_{10} truck unloading: end dump-coal emission factor at western surface coal mining operations (lbs/ton)
EF_t = PM_{10} truck unloading: bottom dump-coal emission factor at western surface coal mining operations (lbs/ton)

Applying the PM_{10} emission factors developed for western surface coal mining operations [ref 3] yields the following coal mining emissions factor:

$$EF_c = (10 \times (0.015 + 0.001 + 0.006)) + 0.225 + 0.00005 + 0.05 + (0.5 \times (0.0035 + 0.033)) = 0.513 \text{ lbs/ton}$$

PM-FIL emission factors are assumed to be the same as PM-PRI emission factors; however there is a small amount of PM-CON emissions included in the PM-PRI emissions but insufficient data exists to tease out the PM-CON portion. In 2006, the EPA adopted new $PM_{2.5}/PM_{10}$ ratios for several fugitive dust categories and concluded that the $PM_{2.5}/PM_{10}$ ratios for fugitive dust categories should be in the range of 0.1 to 0.15 [ref 5]. Consequently, a ratio of 0.125 was applied to the PM_{10} emission factors to estimate $PM_{2.5}$ emission factors for mining and quarrying. A summary of these emission factors is presented in Table 4-89.

Table 4-89: Summary of Mining and Quarrying emission factors

Mining Type	Pollutant Code	Factor Numeric Value	Factor Unit Numerator	Factor Unit Denominator
Coal	PM10-PRI	0.513	LB	TON
Coal	PM10-FIL	0.513	LB	TON
Coal	PM25-PRI	0.064	LB	TON
Coal	PM25-FIL	0.064	LB	TON
Metallic	PM10-PRI	0.0548	LB	TON
Metallic	PM10-FIL	0.0548	LB	TON
Metallic	PM25-PRI	0.0068	LB	TON
Metallic	PM25-FIL	0.0068	LB	TON
Non-Metallic	PM10-PRI	0.293	LB	TON
Non-Metallic	PM10-FIL	0.293	LB	TON
Non-Metallic	PM25-PRI	0.037	LB	TON
Non-Metallic	PM25-FIL	0.037	LB	TON

4.15.3.2 *Activity*

Emissions were estimated by obtaining state-level metallic and non-metallic crude ore handled at surface mines from the U.S. Geologic Survey (USGS) [ref 6] and mine specific coal production data for surface mines from the EIA [ref 7]. Emissions were not estimated for underground mining given that emission factors are calculated exclusively for surface activity. Since some of the USGS metallic and non-metallic minerals waste data associated with ore production are withheld to avoid disclosing company proprietary data, an allocation procedure was developed to estimate the withheld data. For states with withheld waste data, the state fraction of national ore production was multiplied by the national undisclosed waste value to estimate the state withheld data. In addition, the USGS only reports metallic and non-metallic minerals production data separately at the national-level (e.g., the production data are combined at the state-level). To estimate metallic versus non-metallic ore production and associated waste at the state-level, the state-level total production and waste data were multiplied by the national metallic or non-metallic percentage of total production.

4.15.3.3 *Allocation: updated in 2014v2 NEI*

State-level metallic and non-metallic crude ore and associated waste handled was allocated to the county-level using employment. Specifically, state-level activity data were multiplied by the ratio of county- to state-level number of employees in the metallic and non-metallic mining industries. See Table 4-90 for a list of these NAICS codes.

Table 4-90: NAICS codes for metallic and non-metallic mining

NAICS Code	Description
2122	Metal Ore Mining
212210	Iron Ore Mining
21222	Gold Ore and Silver Ore Mining
212221	Gold Ore Mining
212222	Silver Ore Mining
21223	Copper, Nickel, Lead, and Zinc Mining
212231	Lead Ore and Zinc Ore Mining
212234	Copper Ore and Nickel Ore Mining
21229	Other Metal Ore Mining
212291	Uranium-Radium-Vanadium Ore Mining
212299	All Other Metal Ore Mining
2123	Nonmetallic Mineral Mining and Quarrying
21231	Stone Mining and Quarrying
212311	Dimension Stone Mining and Quarrying
212312	Crushed and Broken Limestone Mining and Quarrying
212313	Crushed and Broken Granite Mining and Quarrying
212319	Other Crushed and Broken Stone Mining and Quarrying
21232	Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying
212321	Construction Sand and Gravel Mining
212322	Industrial Sand Mining
212324	Kaolin and Ball Clay Mining
212325	Clay and Ceramic and Refractory Minerals Mining
21239	Other Nonmetallic Mineral Mining and Quarrying
212391	Potash, Soda, and Borate Mineral Mining
212392	Phosphate Rock Mining
212393	Other Chemical and Fertilizer Mineral Mining
212399	All Other Nonmetallic Mineral Mining

Employment data were obtained from the U.S. Census Bureau's 2014 County Business Patterns (*CBP*) [ref 8] - updated from 2012 CBP in the 2014v1 NEI. Due to concerns with releasing confidential business information, the *CBP* does not release exact numbers for a given NAICS code if the data can be traced to an individual business. Instead, a series of range codes is used. To estimate employment in counties with withheld data, the following procedure is used for each NAICS code being computed.

1. County-level data for counties with known employment are totaled by state.
2. #1 subtracted from the state total reported in state-level *CBP*.
3. Each of the withheld counties is assigned the midpoint of the range code (e.g., A:1-19 employees would be assigned 10).
4. These midpoints are then summed to the state level.
5. #2 is divided by #4 as an adjustment factor to the midpoints.
6. #5 is multiplied by #3 to get the adjusted county-level employment.

Note that step 5 adjusts all counties with withheld employment data by the same state-based proportion. It is unlikely that actual employment corresponds exactly with this smoothed adjustment method, but this method is the best option given the availability of the data.

For example, take the 2006 *CBP* data for NAICS 31-33 (Manufacturing) in Maine provided in Table 4-91.

Table 4-91: 2006 County Business Pattern data for NAICS 31-33 in Maine

State FIPS	County FIPS	NAICS	Employment Flag	Number of Employees
23	001	31----		6,774
23	003	31----		3,124
23	005	31----		10,333
23	007	31----		1,786
23	009	31----		1,954
23	011	31----		2,535
23	013	31----		1,418
23	015	31----	F	0
23	017	31----		2,888
23	019	31----		4,522
23	021	31----		948
23	023	31----	I	0
23	025	31----		4,322
23	027	31----		1,434
23	029	31----		1,014
23	031	31----		9,749

1. The total of employees not including counties 015 and 023 is 52801.
2. The state-level *CBP* reports 59,322 employees for NAICS 31----. The difference is 6,521.
3. County 015 is given a midpoint of 1,750 (since range code F is 1000-2499) and County 023 is given a midpoint of 17,500.
4. State total for these two counties is 19,250.
5. 6,521/19,250 = 0.33875.
6. The adjusted employment for county 015 is 1,750*0.33875 = 593. County 023 has an adjusted employment of 17,500*0.33875 = 5,928.

In the event that data at the state level are withheld, a similar procedure is first performed going from the U.S. level to the state level. For example, known state-level employees are subtracted from the U.S. total yielding the total withheld employees. Next the estimated midpoints of the withheld states are added together and compared (by developing a ratio) to the U.S. total withheld employees. The midpoints are then adjusted by the ratio to give an improved estimate of the state total.

4.15.3.4 *Controls*

No controls were accounted for in the emissions estimation.

4.15.3.5 *Emissions Equation and Sample Calculation*

Fugitive dust emissions for mining and quarrying operations are the sum of emissions from the mining of metallic and nonmetallic ores and coal:

$$E = E_m + E_n + E_c$$

where,

E = PM_{10} emissions from mining and quarrying operations
E_m = PM_{10} emissions from metallic ore mining operations
E_n = PM_{10} emissions from non-metallic ore mining
E_c = PM_{10} emissions from coal mining operations

Four specific activities are included in the emissions estimate for mining and quarrying operations: overburden removal, drilling and blasting, loading and unloading, and overburden replacement. Not included are the transfer and conveyance operations, crushing and screening operations, and storage since the dust emissions from these activities are assumed to be well controlled. Emissions for each activity are calculated using the following equation:

$$E = EF \times A$$

where,

E = PM_{10} emissions from operation (e.g., metallic ore, non-metallic ore, or coal mining; lbs)
EF = emissions factor associated with operation (lbs/ton)
A = ore handled in mining operation (tons)

As an example, in 2012 Barbour County, Alabama handled 13,507,583 tons of metallic ore and associated waste, 113,501 tons of non-metallic ore and associated waste, and 0 tons of coal. Mining and quarrying PM_{10}-PRI emissions for Barbour County are:

$$EPM_{10\text{-PRI, Barbour County}} = [(13{,}507{,}583 \times 0.0548) + (113{,}501 \times 0.293) + (0 \times 0.513)]/2000 = 386 \text{ tons}$$

The division by 2000 is to convert from pounds to tons.

4.15.3.6 *Changes from 2011 and 2014v1 Methodology*

For the 2014 NEI, the activity data are updated to year 2012 for the 2014v1 NEI and 2014 for the 2014v2 NEI using the most recent USGS and EIA data on metallic and non-metallic crude ore handled and coal production. The allocation procedure uses 2014 (2012 for 2014v1 NEI) employment data from the U.S. Census Bureau. In addition, the allocation procedure in 2014 allocates state-level metallic and non-metallic activity to the county-level using the respective county fraction of metallic and non-metallic state employees that work in the county. In 2011, the allocation procedure combined the metallic and non-metallic employees to generate a single county allocation factor. The 2014 allocation methodology is an improvement because it more precisely assigns the mining emissions to counties where the mining is occurring.

4.15.3.7 *Puerto Rico and US Virgin Islands Emissions Calculations*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.15.4 References for mining and quarrying

1. United States Environmental Protection Agency. *Generalized Particle Size Distributions for Use in Preparing Size-Specific Particulate Emissions Inventories*, EPA-450/4-86-013, July 1986.
2. United States Environmental Protection Agency, *National Air Pollutant Emission Trends Procedure Document for 1900-1996*, EPA-454/R-98-008, May 1998.
3. United States Environmental Protection Agency, AP-42, Fifth Edition, Volume 1, Chapter 11: Mineral Products Industry, Section 11.9: Western Surface Coal Mining, accessed July 2015.
4. United States Environmental Protection Agency, *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*, EPA-450/4-90-003, March 1990.
5. Midwest Research Institute, Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors, MRI Project No. 110397, November 2006, accessed July 2015.
6. United States Geologic Survey, Minerals Yearbook 2012, accessed July 2015.
7. Energy Information Administration, Detailed data from the EIA-7A and the U.S. Mine Safety and Health Administration, data pulled for year 2014, accessed August 2016.
8. U.S. Census Bureau, 2014 County Business Patterns, accessed August 2016

4.16 Industrial Processes – Oil & Gas Production

4.16.1 Sector description

This sector includes processes associated with the exploration and drilling at oil, gas, and coal bed methane (CBM) wells and the equipment used at the well sites to extract the product from the well and deliver it to a central collection point or processing facility.

4.16.2 Source of data

Table 4-92 shows the nonpoint SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 3 and 4 descriptions are also provided. The leading SCC description is "Industrial Processes; Oil and Gas Exploration and Production;" for all SCCs.

New SCCs, created for the 2014v1 inventory are noted in the table, and additional new SCCs created at State's request for 2014v2, are also indicated with a "v2" in the "New?" column. Several of these new SCCs are not used by EPA but were created for states that wanted to preserve the difference between conventional and unconventional formations for their own reporting needs. Note also that the SCCs in this list are only the SCCs that either the EPA used or the submitting State agencies used in the 2014 NEI. All of the SCCs that the EPA Oil and Gas Tool uses are nonpoint SCCs. There are several point inventory SCCs in the oil and gas production sector as well. Emissions or activity from these SCCs, listed in Table 4-93, are subtracted from nonpoint estimates using in the EPA's Oil and Gas Tool, discussed in the next section.

Table 4-92: Nonpoint SCCs with 2014 NEI emissions in the Oil and Gas Production sector

SCC	New?	Description	EPA	State	Tribe
2310000000		All Processes; Total: All Processes		X	
2310000220		All Processes; Drill Rigs	X	X	
2310000230		All Processes; Workover Rigs		X	
2310000330		All Processes; Artificial Lift	X	X	
2310000550		All Processes; Produced Water	X	X	
2310000660		All Processes; Hydraulic Fracturing Engines	X	X	
2310001000		All Processes; On-shore; Total: All Processes		X	X
2310002000		Off-Shore Oil and Gas Production; Total: All Processes		X	
2310002301		Off-Shore Oil and Gas Production; Flares: Continuous Pilot Light		X	
2310002305		Off-Shore Oil and Gas Production; Flares: Flaring Operations		X	
2310002401		Off-Shore Oil and Gas Production; Pneumatic Pumps: Gas and Oil Wells		X	
2310002411		Off-Shore Oil and Gas Production; Pressure/Level Controllers		X	
2310002421		Off-Shore Oil and Gas Production; Cold Vents		X	
2310010000		Crude Petroleum; Total: All Processes		X	
2310010100		Crude Petroleum; Oil Well Heaters	X	X	
2310010200		Crude Petroleum; Oil Well Tanks - Flashing & Standing/Working/Breathing	X	X	
2310010300		Crude Petroleum; Oil Well Pneumatic Devices	X	X	
2310010700		Crude Petroleum; Oil Well Fugitives		X	
2310010800		Crude Petroleum; Oil Well Truck Loading		X	
2310011000		On-Shore Oil Production; Total: All Processes	X	X	
2310011020		On-Shore Oil Production; Storage Tanks: Crude Oil		X	
2310011100		On-Shore Oil Production; Heater Treater		X	
2310011201		On-Shore Oil Production; Tank Truck/Railcar Loading: Crude Oil	X	X	
2310011450		On-Shore Oil Production; Wellhead		X	
2310011500		On-Shore Oil Production; Fugitives: All Processes		X	
2310011501		On-Shore Oil Production; Fugitives: Connectors	X	X	
2310011502		On-Shore Oil Production; Fugitives: Flanges	X	X	
2310011503		On-Shore Oil Production; Fugitives: Open Ended Lines	X	X	
2310011504		On-Shore Oil Production; Fugitives: Pumps		X	
2310011505		On-Shore Oil Production; Fugitives: Valves	X	X	
2310011506		On-Shore Oil Production; Fugitives: Other		X	
2310011600	v2	On-Shore Oil Production: Artificial Lift Engines		X	
2310012000		Off-Shore Oil Production; Total: All Processes		X	
2310012020		Off-Shore Oil Production; Storage Tanks: Crude Oil		X	
2310012511		Off-Shore Oil Production; Fugitives, Connectors: Oil Streams		X	
2310012512		Off-Shore Oil Production; Fugitives, Flanges: Oil		X	
2310012515		Off-Shore Oil Production; Fugitives, Valves: Oil		X	

SCC	New?	Description	EPA	State	Tribe
2310012516		Off-Shore Oil Production; Fugitives, Other: Oil		X	
2310012521		Off-Shore Oil Production; Fugitives, Connectors: Oil/Water Streams		X	
2310012522		Off-Shore Oil Production; Fugitives, Flanges: Oil/Water		X	
2310012525		Off-Shore Oil Production; Fugitives, Valves: Oil/Water		X	
2310012526		Off-Shore Oil Production; Fugitives, Other: Oil/Water		X	
2310020000		Natural Gas; Total: All Processes		X	
2310020600		Natural Gas; Compressor Engines		X	
2310020700		Natural Gas; Gas Well Fugitives		X	
2310020800		Natural Gas; Gas Well Truck Loading		X	
2310021010		On-Shore Gas Production; Storage Tanks: Condensate	X	X	
2310021011		On-Shore Gas Production; Condensate Tank Flaring		X	
2310021030		On-Shore Gas Production; Tank Truck/Railcar Loading: Condensate	X	X	
2310021100		On-Shore Gas Production; Gas Well Heaters	X	X	
2310021101		On-Shore Gas Production; Natural Gas Fired 2Cycle Lean Burn Compressor Engines < 50 HP		X	
2310021102		On-Shore Gas Production; Natural Gas Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP	X	X	
2310021103		On-Shore Gas Production; Natural Gas Fired 2Cycle Lean Burn Compressor Engines 500+ HP		X	
2310021201		On-Shore Gas Production; Natural Gas Fired 4Cycle Lean Burn Compressor Engines <50 HP		X	
2310021202		On-Shore Gas Production; Natural Gas Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP	X	X	
2310021203		On-Shore Gas Production; Natural Gas Fired 4Cycle Lean Burn Compressor Engines 500+ HP		X	
2310021251		On-Shore Gas Production; Lateral Compressors 4 Cycle Lean Burn	X	X	
2310021300		On-Shore Gas Production; Gas Well Pneumatic Devices	X	X	
2310021301		On-Shore Gas Production; Natural Gas Fired 4Cycle Rich Burn Compressor Engines <50 HP		X	
2310021302		On-Shore Gas Production; Natural Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP	X	X	
2310021303		On-Shore Gas Production; Natural Gas Fired 4Cycle Rich Burn Compressor Engines 500+ HP		X	
2310021310		On-Shore Gas Production; Gas Well Pneumatic Pumps		X	
2310021351		On-Shore Gas Production; Lateral Compressors 4 Cycle Rich Burn	X	X	
2310021400		On-Shore Gas Production; Gas Well Dehydrators	X	X	
2310021401		On-Shore Gas Production; Nat Gas Fired 4Cycle Rich Burn Compressor Engines <50 HP w/NSCR		X	
2310021402		On-Shore Gas Production; Nat Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP w/NSCR		X	
2310021403		On-Shore Gas Production; Nat Gas Fired 4Cycle Rich Burn Compressor Engines 500+ HP w/NSCR		X	

SCC	New?	Description	EPA	State	Tribe
2310021411		On-Shore Gas Production; Gas Well Dehydrators - Flaring		X	
2310021450		On-Shore Gas Production; Wellhead		X	
2310021500		On-Shore Gas Production; Gas Well Completion - Flaring		X	
2310021501		On-Shore Gas Production; Fugitives: Connectors	X	X	
2310021502		On-Shore Gas Production; Fugitives: Flanges	X	X	
2310021503		On-Shore Gas Production; Fugitives: Open Ended Lines	X	X	
2310021504		On-Shore Gas Production; Fugitives: Pumps		X	
2310021505		On-Shore Gas Production; Fugitives: Valves	X	X	
2310021506		On-Shore Gas Production; Fugitives: Other	X	X	
2310021509		On-Shore Gas Production; Fugitives: All Processes		X	
2310021600		On-Shore Gas Production; Gas Well Venting		X	
2310021601		On-Shore Gas Production; Gas Well Venting - Initial Completions		X	
2310021602		On-Shore Gas Production; Gas Well Venting - Recompletions		X	
2310021603		On-Shore Gas Production; Gas Well Venting - Blowdowns	X	X	
2310021604		On-Shore Gas Production; Gas Well Venting - Compressor Startups		X	
2310021605		On-Shore Gas Production; Gas Well Venting - Compressor Shutdowns		X	
2310021700		On-Shore Gas Production; Miscellaneous Engines		X	
2310022000		Off-Shore Gas Production; Total: All Processes		X	
2310022010		Off-Shore Gas Production; Storage Tanks: Condensate		X	
2310022051		Off-Shore Gas Production; Turbines: Natural Gas		X	
2310022090		Off-Shore Gas Production; Boilers/Heaters: Natural Gas		X	
2310022105		Off-Shore Gas Production; Diesel Engines		X	
2310022410		Off-Shore Gas Production; Amine Unit		X	
2310022420		Off-Shore Gas Production; Dehydrator		X	
2310022501		Off-Shore Gas Production; Fugitives, Connectors: Gas Streams		X	
2310022502		Off-Shore Gas Production; Fugitives, Flanges: Gas Streams		X	
2310022505		Off-Shore Gas Production; Fugitives, Valves: Gas		X	
2310022506		Off-Shore Gas Production; Fugitives, Other: Gas		X	
2310023010	Y	Coal Bed Methane Natural Gas; Storage Tanks: Condensate	X	X	
2310023030	Y	Coal Bed Methane Natural Gas; Tank Truck/Railcar Loading: Condensate	X	X	
2310023100	Y	Coal Bed Methane Natural Gas; CBM Well Heaters	X	X	
2310023102	Y	Coal Bed Methane Natural Gas; CBM Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP	X	X	
2310023202	Y	Coal Bed Methane Natural Gas; CBM Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP	X	X	
2310023251	Y	Coal Bed Methane Natural Gas; Lateral Compressors 4 Cycle Lean Burn	X	X	
2310023300	Y	Coal Bed Methane Natural Gas; Pneumatic Devices	X	X	
2310023302	Y	Coal Bed Methane Natural Gas; CBM Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP	X	X	
2310023310	Y	Coal Bed Methane Natural Gas; Pneumatic Pumps	X	X	
2310023351	Y	Coal Bed Methane Natural Gas; Lateral Compressors 4 Cycle Rich Burn	X	X	

SCC	New?	Description	EPA	State	Tribe
2310023400	Y	Coal Bed Methane Natural Gas; Dehydrators	X	X	
2310023509	Y	Coal Bed Methane Natural Gas; Fugitives		X	
2310023511	Y	Coal Bed Methane Natural Gas; Fugitives: Connectors	X	X	
2310023512	Y	Coal Bed Methane Natural Gas; Fugitives: Flanges	X	X	
2310023513	Y	Coal Bed Methane Natural Gas; Fugitives: Open Ended Lines	X	X	
2310023515	Y	Coal Bed Methane Natural Gas; Fugitives: Valves	X	X	
2310023516	Y	Coal Bed Methane Natural Gas; Fugitives: Other	X	X	
2310023600	Y	Coal Bed Methane Natural Gas; CBM Well Completion: All Processes	X	X	
2310023603	Y	Coal Bed Methane Natural Gas; CBM Well Venting - Blowdowns	X	X	
2310023606	Y	Coal Bed Methane Natural Gas; Mud Degassing	X	X	
2310030300	v2	Natural Gas Liquids: Gas Well Water Tank Losses		X	
2310030401		Natural Gas Liquids; Gas Plant Truck Loading		X	
2310111100		On-Shore Oil Exploration; Mud Degassing	X	X	
2310111401		On-Shore Oil Exploration; Oil Well Pneumatic Pumps	X	X	
2310111700		On-Shore Oil Exploration; Oil Well Completion: All Processes	X	X	
2310112401		Off-Shore Oil Exploration; Oil Well Pneumatic Pumps		X	
2310121100		On-Shore Gas Exploration; Mud Degassing	X	X	
2310121401		On-Shore Gas Exploration; Gas Well Pneumatic Pumps	X	X	
2310121700		On-Shore Gas Exploration; Gas Well Completion: All Processes	X	X	
2310122100		Off-Shore Gas Exploration; Mud Degassing		X	
2310321010	Y	On-Shore Gas Production - Conventional; Storage Tanks: Condensate		X	
2310321100	Y	On-Shore Gas Production - Conventional; Gas Well Heaters		X	
2310321400	Y	On-Shore Gas Production - Conventional; Gas Well Dehydrators		X	
2310321603	Y	On-Shore Gas Production - Conventional; Gas Well Venting - Blowdowns		X	
2310400220	Y	All Processes - Unconventional; Drill Rigs		X	
2310421010	Y	On-Shore Gas Production - Unconventional; Storage Tanks: Condensate		X	
2310421100	Y	On-Shore Gas Production - Unconventional; Gas Well Heaters		X	
2310421400	Y	On-Shore Gas Production - Unconventional; Gas Well Dehydrators		X	
2310421603	Y	On-Shore Gas Production - Unconventional; Gas Well Venting - Blowdowns		X	

Table 4-93: Point SCCs in the Oil and Gas Production sector

SCC(s)	Abbreviated description
31000101 through 31000506	Various descriptions; Excludes 31000104 through 31000108 and 31000140 through 31000145, which are in the sector "Industrial Processes – Storage and Transfer"
31088801 through 31088811	Fugitive Emissions; Specify in Comments Field
31700101	Natural Gas Transmission and Storage Facilities; Pneumatic Controllers Low Bleed

The agencies listed in Table 4-94 submitted emissions for this sector; agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-94: Percentage of total Oil and Gas Production NO_X and VOC nonpoint emissions submitted by reporting agency

Region	Agency	NO_X	VOC
2	New York State Department of Environmental Conservation	99	100
3	Pennsylvania Department of Environmental Protection	79	52
3	West Virginia Division of Air Quality	100	100
5	Illinois Environmental Protection Agency	100	100
5	Michigan Department of Environmental Quality	100	100
5	Ohio Environmental Protection Agency	100	100
6	Oklahoma Department of Environmental Quality	100	100
6	Texas Commission on Environmental Quality	100	100
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	100	100
8	Colorado Department of Public Health and Environment	100	100
8	Utah Division of Air Quality	97	85
8	Wyoming Department of Environmental Quality	95	77
9	California Air Resources Board	98	85
10	Alaska Department of Environmental Conservation	7	0

4.16.3 EPA-developed emissions for oil and gas production

The EPA improved the existing Oil and Gas Tool that was developed for the 2011 NEI, which is a MS Access database that uses a bottom up approach to build a national inventory. New for 2014 are two modules (rather than one) for the Oil and Gas Tool: Exploration and Production. This was a necessary change due to the increase in input data; when EPA expanded the specificity of the tool (county-level inputs rather than basin level inputs, some division between conventional and unconventional processes), we reached the limitations of MS Access, so dividing the database into two parts was a necessity. More information on the tool can be found in the documentation provided by ERG for each module on the 2014 NEI Supplemental data FTP site. For the Production module, this documentation is entitled "OilGas_ToolInstruction_Production_v2_2_20170601.pdf," found in zip file "OIL_GAS_TOOL_2014_NEI_PRODUCTION_V2_2.zip". For the Exploration module, this documentation is entitled "OilGas_ToolInstruction_Exploration_v2_3_20170821.pdf," found in zip file "OIL_GAS_TOOL_2014_NEI_EXPLORATION_V2_3.zip".

In general, the tool calculates emissions for each piece of equipment on a well pad (like condensate tanks or dehydrators, for example) in a county or basin, based on average equipment counts taken from either surveys, literature searches, or the GHG reporting program, also accounting for control devices and gas composition in each county. County-level details are important, since well pads can vary significantly from region to region, basin to basin, and county to county. A well site in Denver, CO in the Denver-Julesburg Basin might look very different from one in the Marcellus Shale in PA, due to changes in technology over time (when the well was first drilled), geologic formations of the oil and gas reservoirs themselves (which also changes over time—the ratio of oil to gas changes as pressure in the reservoir is released), and regulations in place guiding the equipment needed on site. The math used in the Oil and Gas Tool is more complex than most other categories, as it uses equations like the Ideal Gas Law (PV=nRT) and mass balances, in conjunction with more traditional emission rate equations (activity x EF = emissions) to calculate emissions; thus, the work is best completed in database format. Overall, there are hundreds of inputs to the Oil and Gas Tool, and these are broken down into three basic categories: activity data, basin factors, and emission factors.

Activity data is taken primarily from a commercially available database developed by DrillingInfo called HPDI (number of wells, oil, gas, condensate and water production, feed drilled, spud counts, and other data). There are cases where this data isn't complete, and in those cases, the state oil and gas commission databases are mined for data. In addition, after verification by the states, sometimes this data is modified to correct the data. Some examples of these are for OH and TX. In the case of Ohio, the state representative noted that the number of conventional versus unconventional well counts was out of proportion, and there were far fewer unconventional wells than HPDI listed. For Texas, the state representative compared the well counts to those of his internal state system, and realized that HPDI data led to double-counting of wells (due to leases). Therefore, these numbers were corrected within the tool, based on corrections by the state.

Basin factors include factors that are secondary to "activity," and include assumptions about equipment counts on a per well basis (e.g. number of pneumatic controllers per well, or average HP of an engine at a well site) as well as gas speciation profiles (fraction of benzene, toluene, xylene or ethylbenzene in natural gas at a particular point in the well pad, e.g. post separator).

Emission factors are also a part of the formula for estimating emissions, and in the Oil and Gas Tool, the nomenclature is set such that we only call the standard national factors, e.g. from AP-42 combustion equations, "emission factors."

These inputs (activity, basin & emission factors) to the tool are filled in by EPA and published with the tool, along with their references. Region specific inputs are preferable and are used when available. Extrapolated inputs from nearby counties in the same basin are then used to fill in gaps in data. National defaults are filled in where no other data is available, and attempts are made to align as much as possible with the Greenhouse Gas Reporting Program (GHGRP) and the Greenhouse Gas Emissions Inventory (GHGEI).

4.16.3.1 *Point Source Subtraction*

Further complication ensues when some states count some wells as point sources, and therefore have a need to subtract these from the nonpoint part of the inventory. The Oil and Gas Tool allows emissions from point sources to be subtracted on an activity or emissions basis. This piece of the puzzle is less perfect, in that if a source has CAP emissions to subtract but not HAPs, the emissions for a single source may be divided across the point and nonpoint parts of the inventory. Thus, when an inventory developer looks at VOC emissions and compares these to a sum of HAP-VOCs, there may appear to be inconsistencies.

<u>Sources of Data Overview and Selection Hierarchy</u>

S/L/Ts have four options for providing data to the NEI for the Oil and Gas sector:

1. Accept the outputs from the EPA Oil and Gas Tools with the EPA-populated defaults,
2. Choose to provide EPA the input data to incorporate in the tools,
3. Run the tools themselves (presumably updating the inputs), or
4. Use their own tools and methodology to provide estimates.

If a reporting agency fails to submit nonpoint data or state a preference via the nonpoint survey, then EPA data was input by default. Table 4-95 summarizes the data, or nonpoint survey option preference, that was submitted by states in the oil and gas sector.

Table 4-95: State involvement with Oil and Gas Production submittals

State	Nonpoint Approach	Point Submittal?
AK	EPA tool for some SCCs (survey) & State submission, state submitted revisions for 2014v2	Yes
AL	no survey, will use EPA tool	Yes
AR	EPA tool	Yes
AZ	EPA tool	Yes
CA	State submitted nonpoint emissions, state submitted revisions for 2014v2	Yes
CO	State submitted nonpoint emissions	Yes
CT	No oil and gas	Yes
FL	EPA tool	Yes
GA	No oil and gas	Yes
IA	No oil and gas	Yes
ID	EPA tool	
IL	State submitted nonpoint emissions, state submitted revisions for 2014v2	Yes
IN	EPA tool	Yes
KS	EPA tool with State inputs	Yes
KY	no survey, will use EPA tool	Yes
LA	EPA tool	Yes
MD	no survey, will use EPA tool	Yes
ME	No oil and gas	Yes
MI	State submitted nonpoint emissions, state submitted revisions for 2014v2	Yes
MN	No oil and gas	Yes
MO	EPA tool	Yes
MS	no survey, will use EPA tool	Yes
MT	no survey, will use EPA tool	Yes
NC	No oil and gas	Yes
ND	EPA tool	Yes
NE	no survey, will use EPA tool	Yes
NJ	No oil and gas	Yes
NM	EPA tool with State inputs	Yes
NV	EPA tool	Yes
NY	State submitted nonpoint emissions, state submitted revisions for 2014v2	Yes
OH	EPA & State	Yes
OK	State CAP submissions, relied on HAP aug for HAPs (point source data lacked HAP emissions, so could not be subtracted)	Yes
OR	EPA tool	
PA	EPA (exploration segment) & State (inadvertently forgot entire exploration segment—e.g., drill rigs, fracking engines, heaters in version 1) , state submitted revisions for 2014v2	Yes

State	Nonpoint Approach	Point Submittal?
SC	No oil and gas	Yes
TN	EPA tool	
TX	State submitted nonpoint emissions, state submitted revisions for 2014v2	Yes
UT	EPA & State, state submitted revisions for 2014v2	Yes
VA	EPA tool	Yes
WI	No oil and gas	Yes
WV	State submitted nonpoint emissions, state submitted revisions for 2014v2	Yes
WY	EPA & State, state submitted revisions for 2014v2	Yes

4.16.4 Notes on observations in 2014 NEI estimates

This section discusses significant changes in the 2014v1 NEI compared to the 2011 NEI. Section 4.16.4.1 lists some known issues in the 2014v1 NEI and Section 4.16.4.2 walks through changes that made it into the 2014v2 NEI.

Alaska: Alaska's VOC emissions went down since 2011. This is because the tool in 2011 assumed storage tanks exist. This was corrected by conversations with industry and AK state representatives, who had a chance to review the tool for 2014, and clarified for EPA that storage tanks do not exist in AK due to the very cold temperatures (everything is sent to pipeline.)

California: On reviewing the data, EPA noticed that CA data when compared to EPA data was very low. A state inventory developer explained that they used the 2011 tool and revised the inputs largely based on an industry survey. This survey, in comparison to default inputs in the EPA Oil and Gas Tool, revealed:

- lower number of dehydrators/well,
- lower activity for artificial lifts (most artificial lifts are electric),
- fewer tanks flared (most use VRUs),
- 30% lower operating hours for compressor engines,
- 50% lower fugitives (no open-ended lines),
- more wells per compressor.

Colorado: Colorado's emissions were lower than they were in 2011, and in fact were closer to the tool emissions than they were in 2011. The nonpoint inventory developer clarified that in the Ozone 9-county nonattainment area, the point source inventory omitted well pad sources from his NEI point source submittal to avoid double counting area (nonpoint) source data. Area source oil and gas production also decreased in the nonattainment area between 2011 to 2014 due to decline in production from old wells and much greater control of emissions from new wells.

Idaho: Idaho is a new state in 2014. There are some new wells that were listed by HPDI.

North Dakota: Emissions for VOC have risen significantly, likely due to increased production in the Bakken Shale area.

Oklahoma: Oklahoma used different SCCs for fugitives. Tagging of EPA SCCs noted in Table 4-96 was necessary to avoid double-counting with the Oklahoma-submitted fugitive emissions shown in Table 4-97 that are not in the EPA oil and gas tool. Oklahoma emissions for the SCCs in Table 4-96 have since been removed from the oil and gas tool. Table 4-97 includes emissions not in the original EPA oil and gas tool and contain all fugitive emissions and malfunctioning pneumatic emissions for Oklahoma.

Table 4-96: EPA oil and gas fugitive SCCs tagged out in Oklahoma in the 2014 NEI

SCC	Description
2310011501	On-Shore Oil Production /Fugitives: Connectors
2310011502	On-Shore Oil Production /Fugitives: Flanges
2310011503	On-Shore Oil Production /Fugitives: Open Ended Lines
2310011505	On-Shore Oil Production /Fugitives: Valves
2310021501	On-Shore Gas Production /Fugitives: Connectors
2310021502	On-Shore Gas Production /Fugitives: Flanges
2310021503	On-Shore Gas Production /Fugitives: Open Ended Lines
2310021505	On-Shore Gas Production /Fugitives: Valves
2310021506	On-Shore Gas Production /Fugitives: Other
2310023511	On-Shore CBM Production /Fugitives: Connectors
2310023512	On-Shore CBM Production /Fugitives: Flanges
2310023513	On-Shore CBM Production /Fugitives: Open Ended Lines
2310023515	On-Shore CBM Production /Fugitives: Valves
2310023516	On-Shore CBM Production /Fugitives: Other

Table 4-97: Additional non-EPA-estimated oil and gas fugitive SCCs Oklahoma submitted in the 2014 NEI

SCC	Description
2310011500	Fugitives: All Processes (Oil wells)
2310021509	Fugitives: All Processes (Gas wells)
2310023509	Fugitives (CBM wells)

Pennsylvania: Pennsylvania's emissions were very low. See "Known Issues" notes in the next Section (4.16.4.1).

Texas: A state inventory developer noted some discrepancies between what TCEQ ultimately submitted to the 2014 NEI and what the EPA Tools would have generated. Many activity data and parameters in the tool were updated by TCEQ, including:

- well counts and production data,
- fraction of gas wells with compressor engines,
- pneumatic device counts,
- hydraulic pump engine equipment profiles,
- mud degassing VOC content,
- piping fugitive VOC content,
- number of dehydrators per well

For well counts and production data, TCEQ explained how reporting at the lease level to the Texas Railroad Commission leads to double counting in the HDPI data. TCEQ explained that leases can contain multiple wells and both of those wells would report production data at the lease level, so then both wells would be listed with the same production (i.e., double counting). For the variable "fraction of gas wells with compressor engines," TCEQ made revisions to the tool to account for the presumption that in general, most wells do not need compression in the first year, and thereafter, in most areas, about a third of wells need compression.

Furthermore, in order to be consistent with OAP use of HPDI data, the Oil and Gas Tool developers shifted some gas wells to oil wells based on the GHGRP GOR definition – about 10% of gas wells were shifted to oil wells (which impacts compressor engine emissions), and about 95% of condensate was shifted to oil (which impacts storage tank and loading loss emissions).

TCEQ's improved inputs to the Oil and Gas Tool were incorporated into the Oil and Gas Tool for 2014 v1.

Wyoming: Wyoming's emissions, in comparison to EPA's estimates for WY, were much lower, in general, for VOC. This can likely be attributed to tighter regulations on emissions. However, some HAPs such as xylenes and benzene were orders of magnitude higher; this should be revisited by EPA in 2014v2.

4.16.4.1 *Known Issues in the 2014v1 NEI*

Dehydrator Emissions: In August 2016, EPA found an issue with the dehydrator emissions algorithm (brought to our attention by the Texas Commission on Environmental Quality. As part of the emissions algorithm for dehydrators, the Tool develops estimates for still vents, reboilers, and flaring. It was discovered that the flaring portion of the emissions algorithm was programmed incorrectly. This error affects only states that used the Tool for Dehydrators (one SCC) and if the "fraction to flares" variable is populated. Where this is the case (which EPA believes is only a few states), the VOC and HAP emissions for the flaring portion are 1000 times higher than they should be. However, for the Tool overall, the VOC changes from the dehydrator issue overestimated VOC by ~8.6%. However, almost all of that (7.8%) was for Texas. The states affected by the dehydrator issue in the Tool include TX, UT, WY, SD, ND, and NM, but TX, UT, and WY provide their own nonpoint oil and gas inventories to the NEI. The % change in VOC for the states using the tool are 2.8% (NM), 1.2% (ND), and 6.1% (SD). Also, the error/fix also affect NOx (3.7% total Tool), and CO (14.3% total Tool). As with VOC, most of the NOx and CO change comes from Texas.

Pennsylvania: We found an issue with PA late in the process (September, 2016). For PA, data submittals were provided by the state (PADEP) for unconventional sources, and by MARAMA on behalf of PA for conventional sources. After reviewing the data submittals, there was a potential issue of category incompleteness for the sector—it appears the entire Exploration module was not submitted. Several large sources (drill rigs, fracking engines, heaters, for example) were not included.

Thus, EPA has decided to allow EPA data to backfill where SCCs were not submitted. For 2014v1, EPA untagged all of EPA data and so there may be some double counting (overlapping SCCs—fugitives and engines—PA uses one SCC for fugitives while EPA uses 5, and PA uses one SCC for engines while EPA uses 3 or more). PA did not complete their nonpoint survey for oil and gas with the specificity needed to reconcile this easily. EPA planned to work with PA DEP to interpret their data submittals prior to 2014v2.

Utah: EPA noticed a very high VOC (leading to high HAPs in the augmentation) number for Uintah County. EPA contacted UT's inventory developer, Greg Mortensen, and he replied that the figure is based off the projection from the 2006 WRAP inventory. Utah has not used the Oil and Gas Tool. The 2006 base year for dehydrators (15,327 tons) is grown by the gas production growth factor (2006 vs 2014 production) which is approximately 1.52. This results in about 23,000 tons of VOC for 2014. However, they are in the midst of incorporating some new data they have collected in Uintah County based on a survey they've conducted on operators in the area. According to Greg, this figure will be reduced to around 3,686 tons in Uintah County when they substitute the numbers from the producer inventory we recently collected. Utah expected to make this correction in the 2014v2 NEI.

4.16.4.2 *Updates in the 2014v2 NEI*

Activity Updates

Activity was updated for 2014v2, using most current available HPDI data. Also, based on comments from the Environ/Ramboll study of Oil and Gas in the NEI, activity associated with CO_2 wells were removed. Some double counting in a few counties was eliminated. WV DPE provided its own numbers for production and exploration, and this data was added to the tool. Overall, this resulted in only a few changes in oil of note from 2014v1: AR down 27%, VA up 26%, and WV down 63%. Natural gas production changes of note from 2014v1: VA down 37%, WV up 20%, AL down 5% and AK up 5%.

Basin Factors and Emission Factors

Updated gas composition data were obtained from EPA's SPECIATE database and BOEM (Arctic Air Quality Modeling Study) and input into the tool for Associated Gas, Condensate Tanks, Crude Oil Tanks, Dehydrators, Fugitives, Gas Actuated Pumps, Liquids Unloading, Loading Operations, Pneumatic Devices, and Well Completions for certain counties in 10 states.

Flare VOC and Formaldehyde emission factors were updated based on AP-42 updates (Section 13.5, 12/2016) and SPECIATE updates (Profile #FLR99) to 0.66 (lb/MMBtu) and 0.08302 (lb/MMBtu), respectively.

Updated basin-level "WELLHEAD_FRACTION_GASWELLS_NEED_COMPRESSION" values were derived from data submitted to EPA under Subpart W of the GHGRP for 2015. Counties previously using EPA default values (based on the 2012 CenSARA study) were updated, and existing state or RPO-supplied data were retained. The default factor was lowered from 0.208 (compressors/well) to 0.078 (compressors/well), and was used where no updated basin- level data was available from the 2015 GHGRP data.

Based on guidance received from Madeleine Strum that the current AP-42 carbon tetrachloride factors used in the tool are based only on "Non-Detect" values, emission factors for carbon tetrachloride were removed from the tool for compressor engines and artificial lift engines. Emission factor updates were made to certain basin factor data in the Permian and San Juan Basin counties in NM, based on data provided by NM/WRAP. Updates were also made to wellhead compressor engine sizes and loads, fraction of wells needing compression, and crude and condensate tank flare fractions in TX based on data provided by TCEQ.

Tool Updates

There were a few other updates that corrected algorithms. For example, the tool was updated to apply the same VOC control percentages to HAPS from lateral compressor engines as is currently done for well pad compressor engines.

Corrections to Tagging

Another error in the 2014v1 NEI was corrected. EPA inadvertently allowed several EPA data SCCs of Oil and Gas Production into the final 2014v1 NEI selection. This was since corrected, and now there's no additional EPA data in the 2014v2 NEI, resulting in lower emissions overall for Colorado.

State Resubmissions

Several states resubmitted data during the window opening between the 2014v1 and 2014v2 NEI. This included WY, UT, OK, WV, and CO.

Utah, for the most part, asked for no changes between versions on tagging. They submitted zeroes for anything they didn't want EPA data on, but still needed some EPA data, like mud degassing. UT also does not submit HAPs and relies on EPA for HAP augmentation. Utah resubmitted produced water ponds—the emission factor for the ponds was too high in 2014v1. They replaced the EF and used a hybrid approach (not based on throughput) and this only affected VOC in 2 counties and 2 SCCs. VOC decreased in the SLT submission significantly—by about half for this SCC.

WY emissions changed significantly. Due to budget constraints, they weren't able to submit a complete inventory (they estimated it covered about 80%) in time for 2014v1, but were able to submit corrections in time for 2014v2.

4.17 Miscellaneous Non-Industrial NEC: Residential Charcoal Grilling

4.17.1 Source category description

Residential barbecue grilling emissions include emissions from the burning of charcoal and all types of outdoor meat grilling. Combustion emissions from gas barbecues are not included. Emissions estimates are for charcoal and all types of meat cooked on charcoal, gas, and electric grills. This source category (SCC=2810025000) is one of many components in the Miscellaneous Non-Industrial sector. The SCC description is "Miscellaneous Area Sources; Other Combustion; Charcoal Grilling - Residential (see 23-02-002-xxx for Commercial); Total".

4.17.2 Source of data

The 2014 NEI was the first time that EPA has provided estimates for this source category; these emissions were not covered on a national basis for previous inventory years. Members of the NOMAD Committee (ID and TX) were instrumental in developing this methodology. An inventory developer in Idaho developed the method, based on one used in Idaho for many years. An inventory developer from TCEQ then created a tool in MS Access, and provided instructions, which makes the method easy to use for all reporting agencies.

This source category includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-98 submitted 100% of their $PM_{2.5}$ emissions for this sector; agencies not listed used EPA estimates for the entire sector.

Table 4-98: Percentage of Residential Charcoal Grilling $PM_{2.5}$ emissions submitted by reporting agency

Region	Agency	S/L/T	SCC	$PM_{2.5}$
6	Texas Commission on Environmental Quality	State	2810025000	100
9	Washoe County Health District	Local	2810025000	100
10	Coeur d'Alene Tribe	Tribe	2810025000	100
10	Idaho Department of Environmental Quality	State	2810025000	100
10	Kootenai Tribe of Idaho	Tribe	2810025000	100
10	Nez Perce Tribe	Tribe	2810025000	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	2810025000	100

4.17.3 EPA-developed emissions for residential charcoal grilling

4.17.3.1 *Activity data*

The activity data needed to estimate emissions from residential charcoal grilling is the number of 2013 households from 1-4 units, the amount of charcoal used in 2013, and the amount of meat cooked during outdoor grilling on charcoal, gas, and electric grills. None of the activity data was updated for the 2014v2 NEI. The household data was obtained from the US Census Bureau 2013 5-year estimates [ref 1, ref 2]. The fraction of occupied households to total households was used on the total households of 1-4 units to calculate the occupied 1-4 unit households. The amount of charcoal sold in Idaho was calculated (from the Hearth, Patio and Barbeque Association BBQ Statistics total charcoal sold in 2013 [ref 3]) using national occupied 1-4 unit households. The fraction of each state's occupied 1-4 unit households compared to the national occupied 1-4 unit households was used on the total charcoal sold in the United States to get the state portion of charcoal sold. Each county was then apportioned tons of charcoal based on their fraction of the total number of 1-4 unit households in each state. It was assumed that those in larger apartment units would not have the space to have or use an outdoor grill.

The activity data for the weight of meat cooked was calculated using some generally accepted information about charcoal grilling. It is generally assumed that about 30 charcoal briquettes are needed to cook a pound of meat [ref 4]. Information from Kingsford on the average weight of their charcoal briquettes indicated that there are about 17.64262 briquettes/lb of charcoal [ref 5]. Using this figure, the number of briquettes was calculated for each county and divided by 30 to get the total weight of meat cooked with charcoal per county.

The gas and electric grill meat totals were estimated using some HPBA statistics. Their 2011 State of the Barbecue Industry Report [ref 6] estimated that households with charcoal grills cook about 27 times per year. Those with gas grills cook about 45 times per year. The later reports don't have this information, so the assumption is that it has remained about the same. The HPBA 5-year average sales figures indicate that about 41% of the grills sold were charcoal grills [ref 7], and the other 59% are gas/electric grills [ref 8]. Since the number of grilling events for charcoal grills is 27 compared to 45 grilling events for gas/electric grills, and only 41% of grilling households have charcoal grills, estimating the amount of meat cooked by the other methods is more complicated.

There were about 2,774 tons of meats cooked in Idaho from charcoal grilling. So, we have gas/electric meat cooked (the unknown) / charcoal meat cooked = (gas/electric grilling events * the percent of gas/electric grills) / (charcoal grilling events * the percent of charcoal grills) * (total charcoal meat cooked in Idaho) + total charcoal meat cooked in Idaho = total meat cooked in Idaho from all grilling. The whole formula would be: total meat grilled / 2,775 = (45*59%) / (27*41%) * 2775 + 2775 = 9,431 tons of meat cooked from all barbecue methods in Idaho. Or take the amount of meat from charcoal grilling and multiply by 3.3984, which will give about the same result (total meat estimated / charcoal meat grilled).

Emissions from charcoal lighting fluid can also be estimated for each county. The HPBA estimates that about 37% of those who use charcoal also use lighter fluid to start their grills [ref 10]. They also estimate that about 80% of households have a grill of some type [ref 7]. The number of charcoal lighter fluid households is estimated by taking 80% of the households and multiplying by the 41% using charcoal grills. Then take 37% of those to estimate the number of households using the lighter fluid. Each of these would then have about 27 barbecue events per year. Lighter fluid is estimated to emit about 0.02 lbs of VOC per barbecue event ref 11]. The resulting formula is:

1-4 unit occupied households * 80% with grills * 41% with charcoal grills * 37% using lighter fluid * 0.02 lbs of VOC.

4.17.3.2 *Emission factors: updated for 2014v2 NEI*

CAP emission factors for charcoal grilling were obtained from "Emissions from Street Vendor Cooking Devices" [ref 9], an EPA report developed by the U.S.-Mexico Border Information Center on Air Pollution. This same report indicates that most of the PM and VOC emissions come from the cooking of meat. The CO and NOx emissions come from the burning of the charcoal. So, all VOC and HAPs from VOC, and the PM_{10}/$PM_{2.5}$ emissions use the total tons of meat cooked to estimate emissions. The CO and NOx emissions were estimated using the total tons of charcoal used for cooking. Idaho used averages from Table E-2 of that report which summarizes the g/kg emissions per weight of both charcoal and meat. Tables 3-1 through 3-4 of the EPA report were used for estimating HAPs emissions. These were averaged and used where they match up with pollutants in the EPA NEI pollutant list. The test results from charcoal-only and the one test with a cover were not used in the averages. New for 2014v2, the HAP emission factors were revised to correct the issue where the sum of HAP VOC emissions exceeded the VOC emissions; the new HAP VOC emission factors for 2014v2 are now based on "commercial cooking underfired charbroiling" (SCC 2302002200). The g/kg emission factors were converted to lb/ton (factor of 2). The resulting emission factors are listed in Table 4-99.

Table 4-99: Residential Charcoal Grilling emissions factors (lb/ton)

Code	Pollutant	Emissions Factor
CO	CO	3.314E+02
NOX	NOx	7.111E+00
PM25-PRI	$PM_{2.5}$ Primary	1.474E+01
PM10-PRI	PM_{10} Primary	1.842E+01
VOC	VOC	1.703E+00
106990	1,3-Butadiene	1.779E-02
540841	2,2,4-Trimethylpentane	1.915E-03
91576	2-Methylnaphthalene	8.112E-03
100027	4-Nitrophenol	1.628E-02
208968	Acenaphthylene	2.552E-03
75070	Acetaldehyde	1.850E-01
98862	Acetophenone	4.377E-03
120127	Anthracene	1.860E-05
71432	Benzene	1.407E-02
132649	Dibenzofuran	4.159E-03
16672392	Diethyl Phthalate	1.427E-02
100414	Ethyl Benzene	1.864E-03
206440	Fluoranthene	6.780E-05
86737	Fluorene	1.547E-03
50000	Formaldehyde	2.342E-01
110543	Hexane	7.456E-03
108383	M-Xylene	1.017E-03
91203	Naphthalene	1.523E-03
95476	O-Xylene	1.864E-03
85018	Phenanthrene	2.050E-04
108952	Phenol	5.007E-02
123386	Propionaldehyde	8.541E-02
106423	P-Xylene	1.017E-03
129000	Pyrene	9.660E-05

Code	Pollutant	Emissions Factor
100425	Styrene	3.232E-01
108883	Toluene	6.778E-03

Lighter fluid VOC emissions were estimated [ref 10] to be 0.02 lbs per barbecue event as noted above. These were added to the VOC emissions estimated from the grilling of meat since there is no separate SCC to list these emissions.

Emission calculations are based on the activity data of tons of meat or charcoal used per county multiplied by the g/kg of meat or charcoal emission factors converted to lb/ton.

4.17.3.3 *Control Factors*

No control measures are assumed for this category.

4.17.3.4 *Example Calculation*

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

$$E_{x,p} = A_x \times EF_{x,p}$$

where:

$E_{x,p}$ = annual emissions for category x and pollutant p;
A_x = calculated pounds of meat or charcoal associated with category x;
$EF_{x,p}$ = emission factor for category x and pollutant p (pound/ton of meat or charcoal).

<u>Example</u>

The 2013 1-4 unit occupied households for Ada County was 129,646. Using the fraction of the Ada County population compared to Idaho, the total tons of charcoal used in Ada County was 977.2 tons or 1,954,334.3 pounds. Using 30 briquettes needed to cook a pound of meat and figuring that there are 17.64262 charcoal briquettes in a pound of charcoal, the amount of charcoal grilled meat cooked in Ada County was 574.7 tons. (1,954,334.3 lbs of charcoal × 17.64262 briquettes/lbs of charcoal / 30 briquettes/lb of meat cooked / 2000 to convert to tons). Then using the formula noted above, the total meat cooked from all grilling in Ada County was 1,952.9 tons. The calculation would be: 574.7 * 3.3984, or 574.7 * (45*59%) / (27*41%) * 574.7) + 574.7 = 1,952.9.)

The emission factor for PM10-PRI is 18.42 lb/ton of meat grilled

$E_{PM10\text{-}PRI}$ = 1,952.9 tons meat grilled × 18.42 pounds PM10-PRI/ton of meat grilled / 2000
= 17.99 tons PM10-PRI

4.17.4 References for residential charcoal grilling

1. U.S. Census Bureau. Community Facts, Housing, Selected Housing Characteristics, American Community Survey 5-Year Estimates, accessed April 2015.
2. U.S. Census Bureau. Guided Search, Selected Housing Characteristics, American Community Survey 5-Year Estimates (DP04) Counties.
3. Hearth, Patio and Barbecue Association (HPBA), Statistics/Barbecue Statistics/Charcoal Shipments for 2013, accessed April 2015.
4. Hearth, Patio and Barbecue Association (HPBA) 3/23/2015 email from Jessica Boothe on how many

briquettes to use to cook a pound of meat or chicken.
5. Kingsford email on the weight of their charcoal briquettes 4/11/2015.
6. Hearth, Patio & Barbecue Association (HPBA), 2011 State of the Hearth Industry Report, accessed April 2015.
7. Hearth, Patio & Barbecue Association (HPBA), 2014 State of the Barbecue Industry Report, accessed April 2015.
8. Hearth, Patio and Barbecue Association (HPBA), Statistics, BBQ Grill Shipments, accessed April 2015.
9. U.S. Environmental Protection Agency, 1999. Emissions from Street Vendor Cooking Devices (Charcoal Grilling), EPA/600/SR-99/048, June 1999, accessed October, 2012.
10. Hearth, Patio and Barbecue Association (HPBA) 3/23/2015 email from Jessica Boothe on how many people with charcoal grills use lighter fluid.
11. South Coast Air Quality Management District. October 5, 1990. Rule 1174. Control of Volatile Organic Compound Emissions from the Ignition of Barbecue Charcoal, accessed May 2015.

4.18 Miscellaneous Non-Industrial NEC: Portable Gas Cans

4.18.1 Source category description

There are several sources of emissions associated with portable gas cans, hereafter referred to as PFCs (portable fuel containers). These sources, used for gasoline, include vapor displacement and spillage while refueling the gas can at the pump, spillage during transport, permeation and evaporation from the gas can during transport and storage, and vapor displacement and spillage while refueling equipment. Vapor displacement and spillage while refueling nonroad equipment from PFCs are included in the nonroad inventory. This section describes how other types of PFC emissions are accounted for in the NEI. This source category is one of many components in the Miscellaneous Non-Industrial sector.

4.18.2 Source of data

Table 4-100 shows the SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 3 and 4 descriptions are also provided. The leading SCC description is "Storage and Transport; Petroleum and Petroleum Product Storage" for all SCCs.

Table 4-100: SCCs with 2014 NEI emissions for PFCs

SCC	Description	EPA	State	Tribe
2501011011	Residential Portable Gas Cans; Permeation	X	X	X
2501011012	Residential Portable Gas Cans; Evaporation (includes Diurnal losses)	X	X	X
2501011013	Residential Portable Gas Cans; Spillage During Transport	X	X	X
2501011014	Residential Portable Gas Cans; Refilling at the Pump - Vapor Displacement	X	X	
2501011015	Residential Portable Gas Cans; Refilling at the Pump - Spillage	X	X	
2501012011	Commercial Portable Gas Cans; Permeation	X	X	X
2501012012	Commercial Portable Gas Cans; Evaporation (includes Diurnal losses)	X	X	X
2501012013	Commercial Portable Gas Cans; Spillage During Transport	X	X	X
2501012014	Commercial Portable Gas Cans; Refilling at the Pump - Vapor Displacement	X	X	
2501012015	Commercial Portable Gas Cans; Refilling at the Pump - Spillage	X	X	

This source category includes data from the S/L/T agency submitted data and the default EPA generated emissions. The agencies listed in Table 4-101 submitted at least VOC emissions; agencies not listed used EPA estimates for all PFC sources. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-101: Percentage of PFC VOC emissions submitted by reporting agency

Region	Agency	S/L/T	VOC
2	New Jersey Department of Environment Protection	State	100
2	New York State Department of Environmental Conservation	State	87
3	Delaware Department of Natural Resources and Environmental Control	State	100
3	Maryland Department of the Environment	State	93
5	Illinois Environmental Protection Agency	State	100
10	Coeur d'Alene Tribe	Tribe	100
10	Nez Perce Tribe	Tribe	100
10	Kootenai Tribe of Idaho	Tribe	100
10	Idaho Department of Environmental Quality	State	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100

4.18.3 EPA-developed emissions for portable gas cans: no change for 2014v2 NEI

PFC emissions are impacted by a 2007 regulation controlling emissions of hazardous pollutants from mobile sources (MSAT2 rule). In this rule EPA promulgated requirements to control VOC emissions from gas cans. The methodology used to develop emission inventories for gas cans was initially described in the regulatory impact analysis for the rule and in an accompanying technical support document [ref 1, ref 2]. The inventory development approach used for the NEI is still based on the analyses done for this rule.

Below, data and methods are described for development of portable fuel container (PFC) inventories in the 2014 National Emissions Inventory (NEI).

VOC Allocation

PFC inventories in the MSAT2 rule were developed for different emissions scenarios in several calendar years (1990, 2005, 2010, 2015, 2020, and 2030) at the State level for 6 categories of emissions: 1) vapor displacement while refilling containers at the pump, 2) spillage while refilling at the pump, 3) spillage during transport, 4) vapor displacement while refueling equipment, 5) spillage while refueling equipment, and 6) permeation and evaporation.

For the NEI, emissions had to separate into commercial and residential fuel container emissions. Total state level PFC emissions were allocated to the categories by using national level residential and commercial emission splits from the MSAT2 rule for each of the categories using the following equations:

$$E_{residential,XXXX,YY} = E \times \left(\frac{Res}{Res + Com} \right) \quad (1)$$

$$E_{commercial,XXXX,YY} = E \times \left(\frac{Com}{Res + Com} \right) \quad (2)$$

where,

E was the emissions of the category being split, XXXX was year, YY was state, and Res and Com were the national residential and commercial PFC emissions.

Permeation and evaporation were also separated as follows:

$$E_{AAA,XXXX,YY,perm} = E_{AAA,XXXX,YY,perm\&evap} \times 0.3387 \quad (3)$$

$$E_{AAA,XXXX,YY,evap} = E_{AAA,XXXX,YY,perm\&evap} \times (1-0.3387) \quad (4)$$

The fraction 0.3387 represents the fraction of combined permeation and evaporative emissions attributable to permeation, based on data from the California Air Resources Board.

Once the state VOC emissions were allocated to the residential and commercial components of the categories, they were assigned SCC codes. Finally, state emissions were allocated to the counties using the ratio of county to State fuel consumption:

$$E_{XXXX,YYYYY,AAA,SCC} = E_{XXXX,YY,AAA,SCC} \times \left(\frac{Consumption_{YYYYY}}{Consumption_{YY}}\right) \quad (5)$$

where,

$E_{XXXX,YYYYY,AAA,SCC}$ where the emissions for year XXXX, county with FIPS code YYYYY, emission scenario AAA, and SCC shown in Table 4-100, $E_{XXXX,YY,AAA,SCC}$ were the state level emissions for year XXXX, state YY, emission scenario AAA, and SCC in Table 4-100, $Consumption_{YYYY}$ was the county fuel consumption and $Consumption_{YY}$ was the state fuel consumption.

Below are descriptions of how 2014 PFC inventories for various types of pollutants were developed for the 2014 NEI, for different groups of SCCs.

4.18.3.1 *VOCs*

Permeation and Evaporation

These emissions are represented by the following SCCs

2501011011 – Residential Portable Fuel Containers: Permeation
2501011012 – Residential Portable Fuel Containers: Evaporation
2501012011 – Commercial Portable Fuel Containers: Permeation
2501012012 – Commercial Portable Fuel Containers: Evaporation

Emissions from these SCCs are impacted by 2007 MSAT rule standards limiting evaporation and permeation emissions from these containers to 0.3 grams of hydrocarbons per day [ref 3]. Inventory estimates developed for calendar year 2018 in EPA's Tier 3 vehicle rule modeling platform [ref 4] reflect the impact of these standards, as well as impacts of RVP and oxygenate use. These Tier 3 inventories were interpolated from earlier 2015 and 2020 MSAT2 rule inventories and assumed 100% E10. They were judged to be reasonable approximations of the 2014 inventory, although increases in activity between 2014 and 2018 means emissions will be overestimated in the 2014 NEI.

Vapor Displacement

Vapor displacement emissions occur while refueling containers at the pump. These emissions are represented by the following SCCs:

25010111014 – Residential Portable Fuel Containers: Refilling at the Pump: Vapor Displacement
25010112014 – Commercial Portable Fuel Containers: Refilling at the Pump: Vapor Displacement

These emissions are not impacted by MSAT2 rule standards, but are impacted by RVP and oxygenate use. Inventory estimates developed for calendar year 2018 in EPA's Tier 3 vehicle rule modeling platform were judged to be reasonable approximations of the 2014 inventory, although increases in activity between 2014 and 2018 means emissions will be overestimated in the 2014 NEI.

Spillage

Spillage occurs during transport and refilling at the pump. These emissions are represented by the following SCCs:

2501011013 – Residential Portable Fuel Containers: Spillage During Transport
2501011015 -- Residential Portable Fuel Containers: Refilling at the Pump: Spillage
2501012013 – Commercial Portable Fuel Containers: Spillage During Transport
2501012015 -- Commercial Portable Fuel Containers: Refilling at the Pump: Spillage

These emissions are not impacted by MSAT2 standards or RVP. However, the composition of the emissions is impacted by oxygenate. VOC emissions for these SCCs are carried forward from 2011.

4.18.3.2 *Air Toxics*

Permeation, Evaporation and Vapor Displacement

MSATs found in liquid gasoline will be present as a component of VOC emissions. These MSATs include benzene, ethanol, and naphthalene. For vapor displacement, toxic to VOC ratios were obtained from headspace vapor profiles from EPAct test fuels [ref 5]. For permeation emissions, vehicle permeation speciation data from Coordinating Research Council (CRC) technical reports E-77-2b and E-77-2c were used [ref 6, ref 7]. We relied on three-day diurnal profiles from the CRC data. For evaporative emissions resulting from changes in ambient temperatures, speciation data from the Auto/Oil program were used for E0 and E10 [ref 8]. Table 4-102 lists the toxic to VOC ratios for each type of PFC emission.

Table 4-102: Toxic to VOC ratios for PFCs

Pollutant	Process	Speciation Surrogate	E0	E10
Benzene	Vapor Displacement	Vehicle Headspace	0.0077	0.0087
Benzene	Permeation	Vehicle Permeation	0.0250	0.0227
Benzene	Evaporation	Vehicle Evap	0.0336	0.0340
Naphthalene	Vapor Displacement	Vehicle Headspace	0.0000	0.0000
Naphthalene	Permeation	Vehicle Permeation	0.0004	0.0004
Naphthalene	Evaporation	Vehicle Evap	0.0004	0.0004
Ethanol	Vapor Displacement	Vehicle Headspace	0	0.0645

Pollutant	Process	Speciation Surrogate	E0	E10
Ethanol	Permeation	Vehicle Permeation	0	0.2020
Ethanol	Evaporation	Vehicle Evap	0	0.1190

Emissions of other air toxics for permeation, evaporation, and vapor displacement were all estimated from the EPAct headspace vapor displacement profile for E10 (SPECIATE profile 8870). Toxic to VOC ratios are provided in Table 4-103.

Table 4-103: Toxic to VOC ratios for other HAPs vapor displacement, permeation and evaporation

Pollutant	Toxic to VOC Ratio
Ethylbenzene	0.0068
Hexane	0.0616
Toluene	0.0521
Xylenes (o,m,p)	0.0300
2,2,4-Trimethylpentane	0.0540

Spillage

Since spillage emissions were carried forward from the 2011 NEI, the HAP estimation approach for these emissions reflects the methods used for that inventory. The methods used in the 2011 NEI are described below.

To calculate the benzene emissions for each PFC SCC in each county the following formulas was used:

$$Benzene_{XXXX,YYYY,SCC} = VOC_{XXXX,YYYY,SCC} \times \left(\frac{Benzene_{refuel,XXXX,YYYY}}{VOC_{refuel,XXXX,YYYY}} \right) \times 0.36 \quad (6)$$

where,

XXXX was the year, YYYYY was the FIPS code of the county, and SCC was an SCC code shown in Table 4-100.

In the equations the factor 0.36 represents an adjustment based on the nationwide percentage of benzene in gasoline vapor from gasoline distribution with an RVP of 10 psi at 60˚F [ref 9]. This factor is based on the ratio of the percentage of benzene in gasoline vapor from gasoline distribution of 0.27%, divided by the percentage of benzene in vehicle refueling emissions of 0.74% benzene in vehicle refueling emissions [ref 1].

For all other HAPs, the PFC emissions were created by multiplying the PFC VOC emissions by the county-level ratio of HAP LDGV evaporative emissions by the VOC LDGV evaporative emissions for the county or:

$$HAP_{XXXX,YYYY,SCC} = VOC_{XXXX,YYYY,SCC} \times \left(\frac{HAP_{LDGV,XXXX,YYYY}}{VOC_{LDGV,XXXX,YYYY}} \right) \quad (7)$$

, where the subscripts are as denoted previously. Using the LDGV evaporative emissions means only HAPs in the onroad inventory with LDGV evaporative emissions would have PFC emissions. Naphthalene was also multiplied by a factor of 0.0054, based on data from the same study used to adjust benzene, where the where the percentage of naphthalene in VOC from gasoline distribution vapor emissions was 0.00027, in contrast to about 0.05% naphthalene in vehicle refueling emissions from highway vehicles.

One modification was made to spillage estimates from the 2011 NEI. The 2011 inventory did not account for impacts of the fuel benzene standard implemented in 2011 because of the 2007 MSAT [ref 1]. This rule established a 0.62% volume standard for benzene, whereas the national average benzene content standard prior to the rule was about 1.0%. Thus, PFC benzene emissions for these SCCs were scaled by a ratio of 0.62/1 to account for impacts of this rule.

4.18.4 References for PFCs

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3. Federal Register. 2007. Control of Hazardous Air Pollutants from Mobile Sources. 72 (37): 8428-8570.
4. U.S. EPA. 2014. Emissions Modeling Technical Support Document: Tier 3 Motor Vehicle and Emission and Fuel Standards. Office of Air Quality Planning and Standards, Research Triangle Park, NC, Report No. EPA-454/R-13-003, February 2014.
5. U. S. EPA. 2011. Hydrocarbon Composition of Gasoline Vapor Emissions from Enclosed Fuel Tanks. Office of Research and Development and Office of Transportation and Air Quality. Report No. EPA-420-R-11-018. EPA Docket EPA-HQ-OAR-2011-0135.
6. U. S. EPA. 2010. Evaporative Emissions from In-Use Vehicles: Test Fleet Expansion (CRC E-77-2b). Prepared by Harold Haskew and Associates for Assessment and Standards Division, Office of Transportation and Air Quality, October, 2010.
7. Coordinating Research Council. 2010. Study to Determine Evaporative Emission Breakdown, Including Permeation Effects and Diurnal Emissions, Using E20 Fuels on Aging Enhanced Evaporative Emissions Certified Vehicles. Report No. E-77-2c.
8. Auto/Oil Air Quality Improvement Research Program. 1996. Phase I and II Test Data. Prepared by Systems Applications International, Inc.
9. Hester, Charles. 2006. Review of Data on HAP Content in Gasoline. Memorandum from MACTEC to Steve Shedd, U. S. EPA, March 23, 2006. This document is available in Docket EPA-HQ-OAR-2003-0053.

4.19 Mobile - Commercial Marine Vessels

The 2014v2 NEI includes emissions from commercial marine vessel (CMV) activity in the 50 states, Puerto Rico, and US Virgin Isles, out to 200 nautical miles from the US coastline.

4.19.1 Sector description

The CMV sector includes boats and ships used either directly or indirectly in the conduct of commerce or military activity. The majority of vessels in this category are powered by diesel engines that are either fueled with distillate or residual fuel oil blends. For the purpose of this inventory, we assume that Category 3 (C3) vessels primarily use residual blends while Category 1 and 2 (C1 and C2) vessels typically used distillate fuels.

The C3 inventory includes vessels which use C3 engines for propulsion. C3 engines are defined as having displacement above 30 liters per cylinder. The resulting inventory includes emissions from both propulsion and auxiliary engines used on these vessels, as well as those on gas and steam turbine vessels. Geographically, the inventories include port and interport emissions that occur within the area that extends 200 nautical miles (nm) from the official U.S. shoreline, which is roughly equivalent to the border of the U.S. Exclusive Economic Zone. Only some of these emissions are allocated to states based on official state boundaries that typically extend 3 miles offshore.

The C1 and C2 vessels tend to be smaller ships that operate closer to shore, and along inland and intercoastal waterways. Naval vessels are not included in this inventory, though Coast Guard vessels are included as part of the C1 and C2 vessels.

The CMV source category does not include recreational marine vessels, which are generally less than 100 feet in length, most being less than 30 feet, and powered by either inboard or outboard. These emissions are included in those calculated by the MOVES model; they reside in the nonroad data category and EIS "Mobile - Non-Road Equipment" sectors of the 2014 NEI.

Each of the commercial marine SCCs requires an appropriate emissions type (M=maneuvering, H=hotelling, C=cruise, Z=reduced speed zone) because emission factors vary by emission type. Each SCC and emissions type combination was allocated to a shape file identifier in the nonpoint inventory. The allowed combinations are shown in Table 4-104. The default values are those assumed when the actual emission type may be unknown; for example, emissions that occur in shipping lanes are assumed to be 'cruising' and cannot be 'hotelling', which only occurs at ports. Port "Ports_Mar2017.zip" and underway "ShippingLanes_Apr25017.zip" GIS shape files used in 2014v2 are available on the2014v2 Supplemental Rail and CMV Data FTP site.

Table 4-104: CMV SCCs and emission types in EPA estimates

SCC	Description	Allowed	Default
2280002100	Marine Vessels, Commercial Diesel Port	M	M
2280002200	Marine Vessels, Commercial Diesel Underway	C	C
2280003100	Marine Vessels, Commercial Residual Port	H	H
2280003100	Marine Vessels, Commercial Residual Port	M	H
2280003200	Marine Vessels, Commercial Residual Underway	C	C
2280003200	Marine Vessels, Commercial Residual Underway	Z	C

4.19.2 Sources of data

This source category includes data from the S/L/T agency submitted data and the default EPA generated emissions. The state agencies listed in Table 4-105 submitted at least $PM_{2.5}$, NO_X and VOC emissions; agencies not listed used EPA estimates for all CMV sources. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%). For this sector, there are sub-county-level estimates from EPA that were backfilled for some shape IDs where the state data did not exist. California and Texas also submitted HAP emissions, but the other states only submitted 6 CAPs: CO, NO_X, PM_{25}, PM_{10}, SO_2, and VOC.

Table 4-105: Percentage of CMV $PM_{2.5}$, NO_X and VOC emissions submitted by reporting agency

Region	Agency	$PM_{2.5}$	NO_X	VOC
1	New Hampshire Department of Environmental Services	98	92	97
2	New Jersey Department of Environment Protection	65	57	88
3	Delaware Department of Natural Resources and Environmental Control	96	91	89
5	Illinois Environmental Protection Agency	100	100	100
5	Indiana Department of Environmental Management	100	100	100
5	Michigan Department of Environmental Quality	100	100	100
5	Minnesota Pollution Control Agency	100	100	100
5	Ohio Environmental Protection Agency	100	100	100
5	Wisconsin Department of Natural Resources	100	100	100

Region	Agency	$PM_{2.5}$	NO_X	VOC
6	Louisiana Department of Environmental Quality	0	0	0
6	Texas Commission on Environmental Quality	100	100	100
7	Iowa Department of Natural Resources	100	100	100
7	Missouri Department of Natural Resources	100	100	100
9	California Air Resources Board	100	100	100
10	Washington State Department of Ecology	97	94	94

4.19.2.1 *Significant Revisions for 2014v2 NEI*

Significant changes between versions are:

1. All of the port shapes were redrawn such that emissions would be placed over water and not on port land area. See EPA method documentation for details.

2. New submittals were added for Lake Michigan Air Directors Consortium (*LADCO)* states and Delaware.

EPA's CMV estimates were using activity data from Entrance and Clearance Waterbourne Commerce (both from Army Corps of Engineers) and from a 2007 EPA census of Category 1 and 2 vessel activities. The activity data were adjusted for typical engine loads for the modes of operation and multiplied by emission factors by engine category. The details of these calculation, also available in "CMVv2_2EPAMethodsReference_20180209.pdf" on the on the2014v2 Supplemental Rail and CMV Data FTP site, are provided below. For 2014v2, the Lake Michigan Air Directors Consortium (LADCO) submitted emissions estimate for several states (see Table 4-106). The documentation on those estimates is not discussed here but is available in a stand-alone document "CMVv2_3LADCOMethodsReference_Sept 2015.pdf" on the2014v2 Supplemental Rail and CMV Data FTP site as well.

Where SLT emissions data were submitted, they replaced EPA-default emissions in the 2014 selections. For the 2014v2 NEI, these submitted estimates were re-apportioned according to area where the shape files were redrawn.

Table 4-106: Agencies that provided CMV submittals for the2014v1 and 2014v2 NEI

Agency	Number of Pollutants	Submitted for 2014v1	Submitted for 2014v2
California	58	Y	
Delaware			Y
Illinois	6	Y	Y – LADCO replacement
Indiana	6		Y - LADCO
Iowa	6		Y - LADCO
New Hampshire	6	Y	
Minnesota	6		Y - LADCO
Michigan	6		Y - LADCO
Missouri	6		Y - LADCO
New Jersey	6	Y	
Ohio	6		Y - LADCO
Texas	48	Y	

Agency	Number of Pollutants	Submitted for 2014v1	Submitted for 2014v2
Washington	6	Y	
Wisconsin	6		Y - LADCO
EPA	49		

LADCO provided a file of estimates that EPA submitted on their behalf. The states identified above agreed to the LADCO submittal. The following pollutants were included: CO, CO2, VOC, NOX, PM10-PRI, PM25-PRI. EPA added SO2 based on a ratio of NOx/SO2 of 3.09 for C3 vessels, and EPA estimates were retained for C1 and C2 vessels. HAPs were added based on the toxic fractions used in the EPA estimates.

4.19.3 EPA-developed emissions for commercial marine vessels: revised for 2014v2 NEI

This section summarizes the approach used to estimate emissions including compilation of 1) activity data (kilowatt hours or kW), 2) engine operating load factors, and 3) emission factors HAP speciation profiles.

Regarding vessel activities, the following data sources were used to develop vessel characteristics and quantify traffic patterns:

- **Entrance and Clearance** (E&C) – This data set captures vessels involved in international trade, documenting where a vessel came from and its next port of call [ref 1]. These vessel-specific ship movements were linked to their individual engine characteristics [ref 2] to calculate kilowatt hours. Most of the vessels in this data set are equipped with Category 3 propulsion engines, although some vessels were identified that are equipped with Category 1 and 2 propulsion engines.
- **Waterborne Commerce** (WC) – The U.S. Army Corps of Engineers provided a data set of domestic vessel movements for tugs and barges, bulk carriers, tankers, and other vessels [ref 3]. These data are provided as domestic trips along a defined route and mapped to the NEI ports and shipping lane segments. Typical vessel speeds by vessel type were used in conjunction with the distance associated with each trip to estimate the hours of operation which were applied to the vessels' propulsion power to get kilowatt hours.
- **Category 1 and 2 Study** – For this inventory, the EPA's 2007 Category 1 and 2 vessels census was updated with more recent data, specifically for ferries, survey vessels, ships involved with offshore oil and gas activities, dredging, and U.S. Coast Guard operations. For these smaller vessels, less detailed information was available about their characteristics or traffic patterns, therefore, the kilowatt hours were estimated based on typical operations and applied to typical vessel power ratings.

Note all activity data were adjusted for typical engine loads for the modes of operation included in this study (i.e., cruising, reduced speed zone (RSZ), maneuvering, and hoteling). The adjusted kilowatt hours were applied to EPA emission factors by engine category as follows:

$$\text{Emissions} = EF\left(\frac{g}{kWh}\right) \times \frac{D\ (NM)}{Vs\,\frac{NM}{hr}} \times LF \times Vp\ (kW)$$

Where:

EF	=	EPA Emission factor, in grams per kilowatt-hour (kWh)
D	=	Distance along segment or RSZ (NM)
Vs	=	0.94 x maximum vessel speed = cruising speed or RSZ speed limit (NM/hr)
LF	=	Load Factor (fraction less than 1)

Vp = Vessel Power (kW)

D/Vs is used to estimate operating hours for E&C data and WC data. For C1/C2 study, typical operating hours are used instead. Also, if vessel speed is unknown, typical speed by vessel type was used (nautical miles/hr or knots). More detailed equations are available in Appendix A of the EPA document "Commercial Marine Vessels – 2014 NEI Commercial Marine Vessels Final" [ref 4].

4.19.3.1 *Activity data for entrance and clearance*

Entrance and Clearance

Vessel-specific routing data were available from the U.S. Army Corps of Engineers' 2012 E&C data [ref 1] for approximately 11,000 U.S. and foreign flagged vessels involved in international trade that complies with U.S. Customs and Clearance reporting requirements, as summarized in Table 4-107.

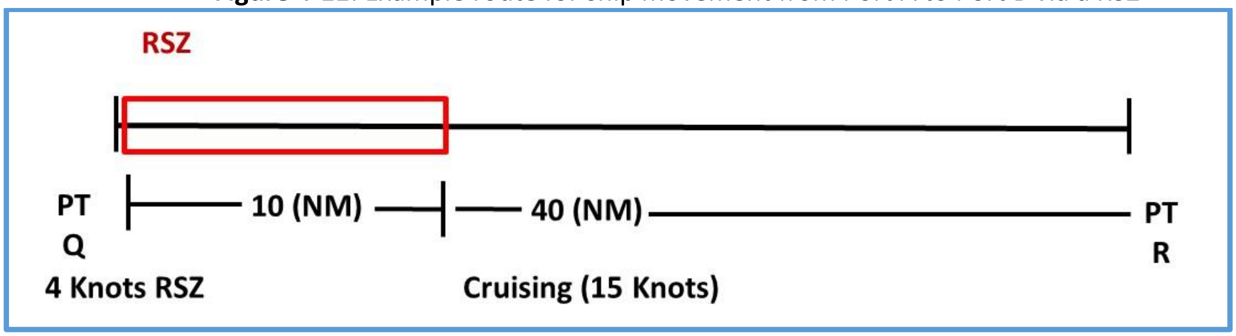
Table 4-107: Vessel-specific routing data

Standard Type	Total Vessel Count	Domestic Flagged	Foreign Flagged
Barge	350	244	106
Bulk Carrier	3,294	11	3,283
Bulk Carrier, Laker	89	35	54
Buoy Tender	4	0	4
Container	1,319	51	1,268
Crude Oil Tanker	754	8	746
Dredger	2	1	1
Drilling	51	7	44
Fishing	248	142	106
FPSO	2	0	2
General Cargo	1,086	24	1,062
Icebreaker	2	0	2
Jackup	4	3	1
LNG Tanker	45	0	45
LPG Tanker	156	0	156
Misc.	47	17	30
Passenger	173	7	166
Pipelaying	14	0	14
Reefer	185	0	185
Research	61	31	30
RORO	92	7	85
Supply	255	197	58
Support	75	34	41
Tanker	1,428	14	1,414
Tug	679	533	146
Vehicle Carrier	465	20	445
Well Stimulation	3	1	2
Total	**10,883**	**1,387**	**9,496**

These vessels were linked to their individual routes based on the originating port and the destination port. For the 2014 NEI, the E&C data were mapped to 7,176 routes comprising 410 unique ports, 174 of which are domestic U.S. ports. The waterway network was also edited to include 1,005 segments associated with RSZs based on the EPA's Regulatory Impact Assessment [ref 5] for Category 3 vessels summarized Appendix B. Where the RSZ speed was unknown, a typical value of 10 knots was used.

To calculate hours of operation, the length of each route was divided by the vessel speed. Where a vessel travels through a RSZ, the vessel speed was reduced, thus increasing the hours of operation along that segment. Figure 4-11 provides an example of a vessel traveling from port Q to port R, moving through a 10 NM RSZ segment followed by a 40 NM normal cruising segment.

Figure 4-11: Example route for ship movement from Port A to Port B via a RSZ



Hours to transit each segment were estimated for each vessel based on the distance traveled and the vessel cruising speed, which was assumed to be 94 percent of the vessel's maximum speed as obtained from Information Handling Services' [ref 2] Register of Ships. These cruising speeds were additionally reduced based on the latest International Maritime Organization (IMO) Greenhouse Gas emission inventory [ref 6] that quantifies actual vessel speeds and engine operating loads for select vessel types, accounting for recent practices to reduce fuel consumption known as slow steaming. The IMO data are presented in Table 4-108.

Table 4-108: IMO-vessel speed data

Ship Type	Size Category	Size Units	Ratio of average at-sea speed to design speed	Percent of total population	Weight amount	Weighted Cruising Speed Factor
Bulk Carrier	0-9999	dwt	0.84	0.9%	0.007403	0.822751023
	10000-34999		0.82	25.1%	0.20571	
	35000-59999		0.82	36.0%	0.295272	
	60000-99999		0.83	31.7%	0.263082	
	100000-199999		0.81	6.2%	0.050227	
	200000+		0.84	0.1%	0.001058	
Container	0-999	TEU	0.77	4.9%	0.038087	0.681508656
	1000-1999		0.73	11.8%	0.086059	
	2000-2999		0.7	12.5%	0.087716	
	3000-4999		0.68	32.8%	0.223116	
	5000-7999		0.65	28.6%	0.185944	
	8000-11999		0.65	9.0%	0.058409	
	12000-14500		0.66	0.3%	0.002176	
	14500+		0.6	0.0%	0	
Oil Tanker	0-4999	dwt	0.8	0.1%	0.001094	0.782982216

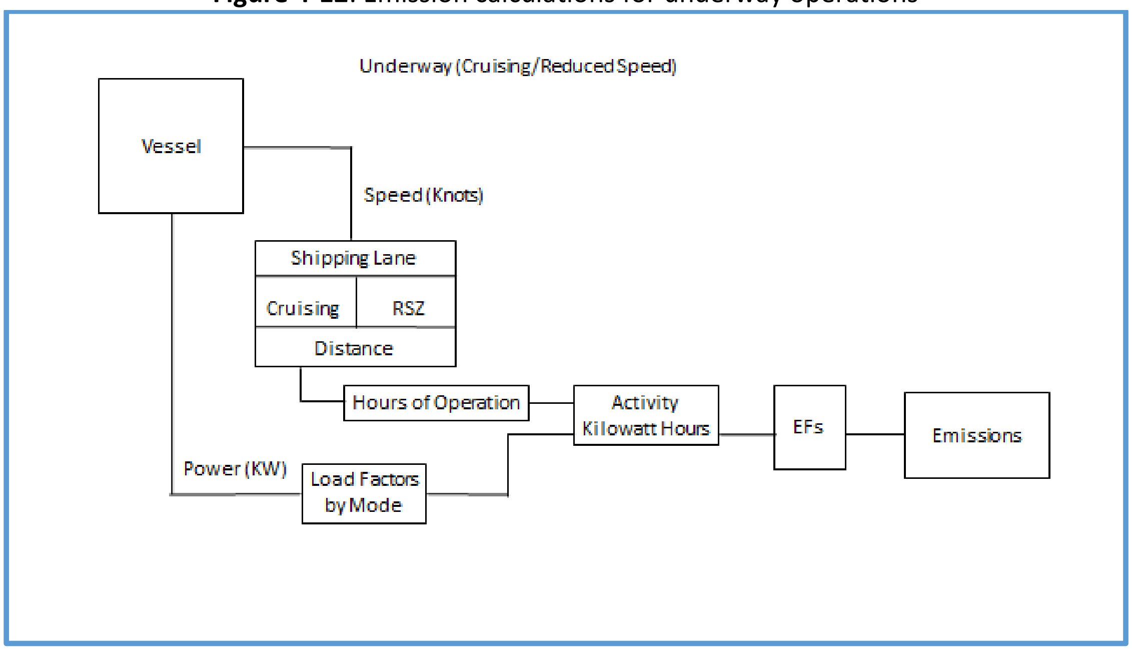
Ship Type	Size Category	Size Units	Ratio of average at-sea speed to design speed	Percent of total population	Weight amount	Weighted Cruising Speed Factor
	5000-9999		0.75	0.3%	0.002052	
	10000-19999		0.76	0.0%	0	
	20000-59999		0.8	3.6%	0.028454	
	60000-79999		0.81	15.6%	0.12632	
	80000-11999		0.78	43.4%	0.338249	
	120000-199999		0.77	32.6%	0.250698	
	200000+		0.8	4.5%	0.036115	

dwt = dead weight tonnage; TEU = twenty foot equivalent units

For RSZs, a vessel's speed was assumed to be the zone's speed unless the vessel's cruising speed was lower. For example, a vessel with a cruising speed of 12 knots traveling through a waterway segment with a reduced speed of 14 knots was assumed to be operating at 12 knots.

The hours of operation were applied to the vessel's power, which was adjusted for typical engine operating loads to get kilowatt hours. In turn, the kilowatt hours were applied to the appropriate EPA emission factor based on the vessel engine's category to estimate criteria pollutant emissions. The flow of emissions calculations for underway vessels is illustrated in Figure 4-12.

Figure 4-12: Emission calculations for underway operations



Vessel characteristics data were compiled from IHS Register of Ships [ref 2] and linked to vessels included in the 2012 E&C data. The vessel characteristics included the following data:

- Vessel identification codes
- Vessel name
- Country of registry
- Call sign

- Vessel type
- Gross/net tonnage
- Vessel power
- Auxiliary engine power
- Piston stroke length/cylinder diameter (to calculate vessel category)
- Maximum vessel speed.

Approximately 89 percent of the E&C vessels could be matched to their characteristics by cross referencing multiple attributes such as IMO identification code, country of registry, gross tonnage, net tonnage, vessel type, and vessel name. For the remaining vessels that could not be matched, vessel attributes were developed for each vessel type based on the matched vessel in the IHS data. If the vessel type was unknown, aggregate attributes derived from all matched vessels in the IHS data set were developed and used. Note that the auxiliary engine data in the IHS data set was poorly populated; therefore, vessel type surrogates were developed based on vessels that reported auxiliary engine power. The vessel power data used in this study are presented in Table 4-109.

Table 4-109: Vessel power attributes by vessel type

Standard Type	Count	Avg Main hrs	Avg Aux kW	Avg Max Speed	Default Vessel Category
Bulk Carrier	3,177	8,990	1,935	14.3	3
Bulk Carrier, Laker	80	7,069	2,216	13.7	3
Buoy Tender	4	4,266		12.6	2
Container	1,218	39,284	7,851	23.2	3
Crude Oil Tanker	731	15,070	2,888	15.1	3
Drilling	7	15,806	12,840	11.7	2
Fishing	123	1,262	272	2.3	1
FPSO	2	18,123		11.5	3
General Cargo	1,020	6,130	1,619	14.6	3
Icebreaker	2	21,844		12.0	2
Jackup	4	1,643	270	3.5	1
LNG Tanker	44	29,607	8,129	19.2	3
LPG Tanker	151	8,557	3,021	15.8	3
Misc.	35	2,805	631	10.0	1
Passenger	168	45,760	4,477	20.4	3
Pipelaying	14	11,355	5,037	12.6	2
Reefer	182	8,930	3,328	18.9	3
Research	55	5,395	1,905	11.2	2
RORO	72	9,479	4,006	16.7	3
Supply	255	3,201	662	10.1	1
Support	73	6,590	2,305	9.7	2
Tanker	1,423	8,474	2,730	14.5	3
Tug	396	3,440	348	7.7	2
Vehicle Carrier	441	13,829	3,729	19.8	3
Well Stimulation	3	7,697	340	8.2	3

Individual vessel movements were compiled as origination and destination pairs for each U.S. port included in the E&C data. The E&C data includes only vessels that enter or leave U.S. waters at some point in the trip. Over 49 percent of the records were for vessels that visit a single U.S. port during a single trip. Similarly, over 49 percent of the records were for vessels that visited multiple U.S. ports in one trip and less than one percent of the records was for between domestic U.S. ports only.

Because the E&C data report the departure of a vessel from a U.S. port and the arrival of the same vessel in the destination port associated with the trip, it was necessary to adjust the vessel movement data to avoid double counting of trips. To avoid the double counting only the entrance or clearance of the trip and not both are counted. Evaluating the duplicate trips was also an important quality check on the E&C data—ideally there should be a duplicate departure and arrival record for every trip, thus validating the completeness of the data. For example, for a vessel traveling from Long Beach to San Diego would typically have four E&C records:

- Arrival at Long Beach
- Departure from Long Beach (to San Diego)
- Arrival at San Diego (from Long Beach)
- Departure from San Diego.

Of the 23,008 unique ship movements for domestic origination and destination pairs, 85 percent of the vessel movements had corresponding arrivals and departures; 3,481 (15 percent) had an odd number of records, indicating that a vessel movement may be missing.

In many cases, the missing vessel movements were associated with an arrival in one port and a departure from an adjacent port, suggesting that the missing vessel movement was between the two adjacent ports. For example, the data may show only three records:

- Arrival at Long Beach
- Departure from Los Angeles (to San Diego)
- Arrival at San Diego (from Los Angeles)
- Departure from San Diego.

This dataset would thus suggest a missing Los Angeles to Long Beach trip.

To account for this type of error, adjacent ports were aggregated, reducing the unique vessel routes or movements to 19,883. Of the final 19,883 routes, only 4 percent of the vessel movements (attributed to 815 routes) had a missing arrival or departure. Many of the remaining missing ship movements were associated with the U.S. protectorates in the Caribbean Sea, where the arrival and departure information occasionally appeared to be switched.

The issue of duplicate trips was not a concern for foreign vessel movements because the E&C documents arrivals and departures for only U.S. ports, which means that a departure from a U.S. port to a foreign port or an arrival from a foreign port to a U.S. port would always be a unique trip.

Adjustments were also made for Alaskan trips. The E&C data reported activity for 52 Alaskan ports, however, the vast majority of those are small ports and have very little traffic. To capture the majority of emissions, only the top 13 Alaska ports, which accounted for 94 percent of the Alaska traffic, were included. Table 4-110 lists the Alaska ports and associated vessel calls.

Table 4-110: Alaska ports and vessel calls

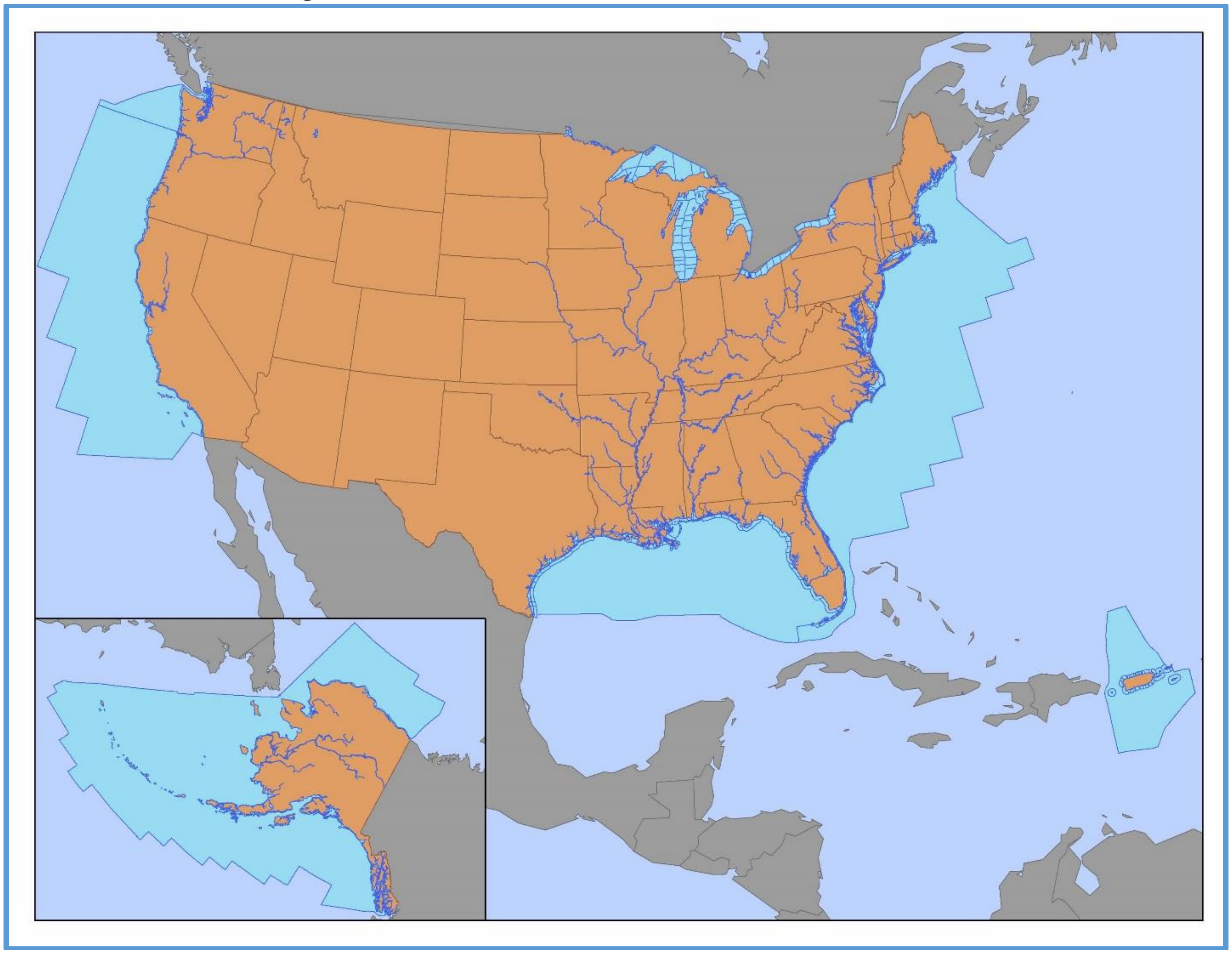
Ports	Total of Count	Domestic	Foreign	Fraction of Alaska Total
Juneau, AK	1,892	1,812	80	0.27
Ketchikan, AK	1,699	1,136	563	0.20
Skagway, AK	1,390	1,330	60	0.20
Anchorage, AK	563	526	37	0.08
Kivalina, AK	481		481	0.03
Sitka, AK	326	302	24	0.05
Iliuliuk Harbor, AK	212	76	136	0.02
Dutch Harbor, AK	196	84	112	0.02
Whittier, AK	182	65	117	0.02
Seward, AK	149	109	40	0.02
Icy Strait, AK	132	110	22	0.02
Wrangell, AK	88	15	73	0.01
Haines, AK	82	81	1	0.01

Once the E&C origination and destination port pairs were defined, trips were routed over a custom waterway network based on the U.S. Army Corps of Engineers' navigable waterway network using a Geographic Information System (GIS) and network analysis. The routes were then intersected with EPA's NEI shapefiles of ports and shipping lanes. Shipping lanes associated with RSZs were coded to allow for adjustment in vessel speed, time spent transiting the RSZ, and engine operating load.

Because U.S. territorial waters extend out 200 nautical miles from the coast (Figure 4-13[11], international vessel routes were mapped only to the U.S. federal waters/international waters boundary. The distance traveled was calculated based on the route the vessel was assigned. Each waterway segment was coded to differentiate normal cruising versus RSZ operations.

[11] These are the official US territorial waters from NOAA, which are generally 200nm but do vary in some places due to foreign entities, etc. Spreading/condensing of emissions depends more on how the emissions were developed than the shapes we use here and is a frequent topic of conversation with modelers.

Figure 4-13: State and federal waters of the United States



Blue/Light Blue = state and federal water boundaries

4.19.3.2 *Activity data for entrance & clearance time spent maneuvering/dockside*

E&C data do not include details about time spent in each ship movement mode. Typical maneuvering times by vessel type were used to estimate time spent in this mode. Maneuvering durations for different vessel types were obtained from Entec's European emission inventory [ref 7] and are presented in Table 4-111. Note half of the maneuvering time presented in Table 4-111 was assumed to be approaching the terminal and half departing from the terminal.

Table 4-111: Estimated maneuvering time by vessel type

Vessel Type	Maneuvering Time (hours)
Bulk Carrier	1
Bulk Carrier, Laker	1
Buoy Tender	1.7
Container	1
Crude Oil Tanker	1.5
General Cargo	1
LNG Tanker	1
LPG Tanker	1

Vessel Type	Maneuvering Time (hours)
Misc.	1
Passenger	0.8
Reefer	1
RORO	1
Tanker	1
Tug	1.7
Vehicle Carrier	1

To quantify the duration a vessel spends dockside, the E&C data were organized chronologically for individual vessels to determine when a vessel arrives at the dock and when it leaves. Some of the dockside durations seemed unreasonably high, indicating that either an arrival or departure was missing or out of sequence. These anomalies were identified and removed from the analysis. The data were then averaged by vessel type to develop port specific dockside duration times. It should be noted that the E&C data recorded the day the vessel arrived and the day the vessel departed. The daily periods were multiplied by 24 hours to get hourly values. If a vessel arrived and departed in the same day it was assumed that the dockside duration was 12 hours.

The EPA provided hourly containership dockside data for 15 ports [ref 8]. For the 2014 NEI, these containership data replaced containership E&C data for the following ports:

- Ports of Los Angeles and Long Beach
- Ports of New York and New Jersey
- Port of Seattle
- Port of Houston
- Port of Baltimore
- Port of Savannah
- Port of Norfolk
- Port of Charleston
- Port of New Orleans
- Port of Mobile
- Port of Miami
- Port of Philadelphia
- Port of Tampa
- Port of San Juan
- Port of Portland

Additionally, dockside duration data were identified for ports that developed their own inventories. These data were assumed to be the highest quality and replaced E&C and EPA containership data. 2014 Detailed port data were obtained from the following ports:

- Port of Los Angeles
- Ports of New York and New Jersey
- Port of San Francisco
- Port of San Diego

4.19.3.3 *Activity data for waterborne commerce*

As with the E&C data, the Army Corps of Engineers Waterborne Commerce Data (WCD) provides vessel trips for individual vessels operating over a specified route. The WCD also includes vessel power ratings and distance of each route. The distance data were evaluated using typical vessel speeds to calculate hours of operation to transit a specified route. Note, hours of operation were adjusted for slower speeds transiting RSZs. The cruising speeds for each vessel type were compiled from a variety of sources. The primary data source was the IHS data; vessels equipped with Category 1 and 2 propulsion engines were identified and grouped by vessel type and averages of the vessel's maximum speed were developed for each grouping. These values are shown in Table 4-112. The cruising speed was assumed to be 94% of the average maximum speed.

Table 4-112: Category 1 and 2 average maximum speed by vessel type

Vessel Type	Vessel Count	Average Maximum Speed (knots)
Bulk Carrier	376.00	10.09
Bulk Carrier, Laker	27.00	13.74
Buoy Tender	197.00	6.90
Container	111.00	8.48
Crude Oil Tanker	44.00	6.97
Drilling	39.00	11.74
Fishing	13,652.00	5.67
Floating Production and Storage Offloading	10.00	4.90
General Cargo	7,179.00	8.09
Icebreaker	27.00	10.52
Jackup	173.00	4.25
LNG Tanker	3.00	9.33
LPG Tanker	183	10.83
Miscellaneous	2,014	6.83
Passenger	3,017	15.67
Pipelaying	280	6.39
Reefer	183	9.62
Research	951	9.79
RORO	1,997	11.28
Supply	3,409	12.98
Support	1,036	10.42
Tanker	2,880	8.28
Tug	15,660	8.54
Vehicle Carrier	20	14.42
Well Stimulation	30	8.63

Because the WCD contain confidential business information not available to the general public, the activity data were aggregated to develop national total activities and reapportioned to appropriate NEI underway shapes. This approach provided reasonable national estimates while protecting the confidential business aspects of the WCD. The spatial allocation was developed in GIS using an approach similar to that used for the E&C data. The WCD were evaluated to identify consolidated routes using both the port and location names for the origins and destinations. For example, routes to and from "St. Thomas, VI" were combined with routes to and from "St. Thomas Harbor Virgin Islands." We also removed routes where the origin and destination were the same, because these records were considered to be inter-terminal maneuvering and are likely to be included in the maneuvering assumptions. This consolidation process reduced the number of unique routes from 40,775 to 27,991. The remaining routes were mapped in GIS using a shortest-distance based network analysis, and the routes were again intersected with NEI shapes to identify which routes passed through each shape. This intersection process identified portions of some routes that passed outside of US waters, for example, from Miami to Puerto Rico. For each route, the total length within US waters was divided by the total length of the route to obtain the percentage of the route activity that occurs in US waters. The activity data were adjusted accordingly to remove kilowatt hours that occurred in international waters.

Next, for each shipping lane segment shape, the number of vessel trips that passed through were totaled.

$$T_a = R_1 + R_2$$

Where:

T_a	=	Total number of trips on segment a
R_1	=	Number of trips on route 1
R_2	=	Number of trips on route 2

The length of the waterway through each shape was calculated and multiplied by the number of trips that occur along the shape. This value was divided by the national total for trips multiplied by the length to determine the percentage of the national total activity to allocate to each shape.

$$P = (T * L)/(NT * NL)$$

Where:

P	=	Percentage of national activity
T	=	Total trips for the NEI underway shape
L	=	Waterway segment length within underway shape
NT	=	National trip total
LN	=	National waterway network length total

Updating the Category 1 and 2 Vessel Census activity data

Since E&C includes only larger internationally-travelling vessels, additional data sources were needed to fill data gaps, particularly for smaller C1 and C2 vessel population involved in domestic traffic.

Dredging

As part of the effort to update the EPA's C1 and C2 vessel data, dredging data were compiled as a new vessel category. To estimate dredging activities for different types of dredging vessels, operating days were obtained from the U.S. Army Corps of Engineers database of dredging contracts for the entire country [ref 9]. This database included contracts from 2012 to 2014. For contracts active since 2012, only the portion of the contracts that were active during 2014 were used in this inventory. The 2014 dredging activities are presented in Appendix C [ref 4] by job name, dredging equipment, and actual operating days.

Operating hours were calculated from the number of days active in 2014, assuming a utilization rate documented in the Category 1/2 Vessel Census of 90% time spent dredging, excluding equipment positioning, maintenance, and refueling times. The U.S. Army Corps of Engineers data did not include horsepower or kW ratings for the engines on the dredging vessels but did include a dredging vessel type. A literature search of the dredging vessel types provided a kW rating for a typical vessel in each category, as summarized in Table 4-113.

Table 4-113: Power rating by dredging type

Type	Contract Code	kW	Source
Bucket or mechanical	B	1,600	Anderson, 2008 [ref 10]
Hopper	H	7,272	TCEQ, 2012, [ref4]
Non-conventional (Specialty) Type	N	2,093	Van Oord 2015 [ref 11]
Pipeline (Cutterhead)	P	7,161	TCEQ, 2012 [ref 4]
Pipeline and Hopper Combination	Y	4080	Robinson et al. 2011 [ref 12]
Undefined	U	5028	Average of compiled dredging data

The typical kW ratings in Table 4-113 were matched by dredge type to each contracted vessel noted in Appendix C [ref 4]. The matched power rating was multiplied by the utilization rate and dredging duration to estimate kW-hours which are summarized in Table 4-114.

Table 4-114: Summary of national kilowatt-hours by dredging vessel type

Type	Total kW-hr
Bucket or mechanical	63,659,520
Hopper	302,526,835
Non-conventional (specialty) type	15,280,574
Pipeline (cutterhead)	654,286,248
Undefined	5,973,264

Dredging activities were spatially apportioned to ship channels based on the job name. The job names indicated general location, such as a bay area or a waterway portion; however, they did not provide sufficient information to precisely locate the dredging activities or even geographic extent of the project. Best effort was given to identify the waterway segments in EPA's GIS shape files that most closely match the limited location information. It should be noted that these activities have been increasing over the past several years to accommodate larger vessels that will be able to transit the new Panama Canal.

Research Vessels

A list of current US research vessels was obtained from the University of Delaware's International Research Ship Information and Schedule database [ref 13]. In the 2007 vessel census study [ref 14], only 31 research vessels were included. Using the University of Delaware's research vessels website for this inventory, 251 vessels were identified. This gave a more accurate representation of C1 research vessels, which were undercounted in the original C1 and C2 census. Twenty-three of these vessels had detailed trip schedules for 2014, and activity in days was determined for these vessels. The list did not have vessel identification numbers or codes, so an online search was implemented to find vessel identification codes for the remaining vessels. Where identification codes could be found, the vessels were linked to research vessels in the IHS database, providing details on the engine power ratings and engine category. However, not all vessels were matched and another online search was implemented to obtain engine power ratings for the unmatched vessels. During this process, 35 vessels were removed from this analysis because information was found that indicated that the vessel was not in service in 2014 or not powered by a diesel combustion engine (e.g. electric powered remotely operated vehicle (ROV)). Detailed results are presented in Appendix D [ref 4]. Summary of research vessel matching activities are provided in Table 4-115.

Table 4-115: Research vessel characteristics matching by reference

Research Vessels Matching	
Original	251
IHS match	77
Online search	109
Annual schedule	23
Removed	35

For research vessels without engine power ratings, the matched vessel data were averaged to provide a default of 732 kW which was used to gap fill missing research vessel power data.

For the 2014 inventory, the duration of each research mission was used when available. For the vessels with no activity data, an average value (220 days converted to 5,280 hours) was obtained from the previous Category 1 and 2 Census report. This default duration data was used to when vessel schedule data were not available. The vessel power data were applied to the duration data to calculate kW-hrs for the research vessels.

Coast Guard

A roster of U.S. Coast Guard vessels was provided by the US Coast Guard's (USCG) External Coordination Division [ref 15]. Among the data given were vessel name, horsepower, and annual underway hours for 246 USCG cutters (Appendix E, ref 4) and over 1,600 smaller boats. Fifty-eight percent of the smaller vessels were gas powered and excluded from this analysis. Also boats which were flagged as retired were also excluded from this analysis. This reduced the Coast Guard Boat list to 652 vessels.

All vessel power ratings were converted from horsepower to kW using the conversion factor 1 HP = 0.7457 kW. The vessel power ratings were multiplied by underway hours also provided by the U.S. Coast Guard to estimate kW-hours per vessel. As Table 4-116 indicates, approximately 95 percent of activity is related to cutter operations and 5 percent is associated with the smaller boats. The Coast Guard data also included general information about where the vessels operated; for the 2014 NEI inventory, each vessel's kW-hours were associated with the area of operation and summarized in Table 4-117.

Table 4-116: Summary of Coast Guard underway activity

Vessel Type	Number of Vessels	Total kW-hours
Cutter	267	2,125,794,310
Boats	652	117,895,003
Total	**919**	**2,243,689,313**

Table 4-117: General location of Coast Guard underway activities

Area	Total kW-hours
Arkansas River	1,025,173
Atlantic	643,954,356
Elizabeth River	92,689,163
Great Lakes	53,675,432
Gulf	129,482,530
Illinois River	343,721
Lower Atchafalaya River	625,932
Mississippi River	3,349,678
Ohio River	1,276,438
Pacific	1,311,967,588
Puget Sound	3,793,450
Tennessee River	1,115,487
Willamette River	354,849
Lake Champlain	35,515
Total	**2,243,689,312**

As the vessel fleet roster quantified at sea hours of operation, an inquiry was sent to the Coast Guard to ask specifically about in-port activities for the cutters. The Coast Guard staff indicated that cutters generally use shore power whenever it is available. There are some instances where maintenance, testing, or training could necessitate the need to run on ship's power. Because of these exceptions, it is estimated that the time on ship's power is no more than 10 hours per 30 days of in-port time. This means that while in-port, a Coast Guard cutter is estimated to be on shore power "99% of the time" [ref 16]. As this response indicates, in-port ship activity is relatively small, so it was not included in this version of the NEI.

Note, currently the NEI does not include emission estimates from U.S. Naval exercises in U.S. waters. It is anticipated that data may be available in 2016 that will allow inclusion of these vessels.

Commercial Fishing

To obtain the most accurate survey of commercial fishing vessels operating in the United States, regional offices of the National Oceanic and Atmosphere Administration (NOAA) were contacted. Of the offices contacted, only Northeast, Southeast (including the Gulf of Mexico), West Coast, and Alaska provided data. Data for the Great Lakes, Puerto Rico, and the U.S. Virgin Islands were not obtained. Upon further research, it was found that fishing vessels in Puerto Rico and the Virgin Islands are almost all powered by small single engines, diesels too small to be considered C1 vessels or gasoline powered vessels not included in this inventory effort.

Due to confidentiality concerns, the responding NOAA regions were not able to provide specific vessel information. The Northeast [ref 17] and Southeast [ref 18] region provided the data on annual number of trips, vessel count, and days absent by port or county, which were used to estimate and spatially allocate annual hours of operation.

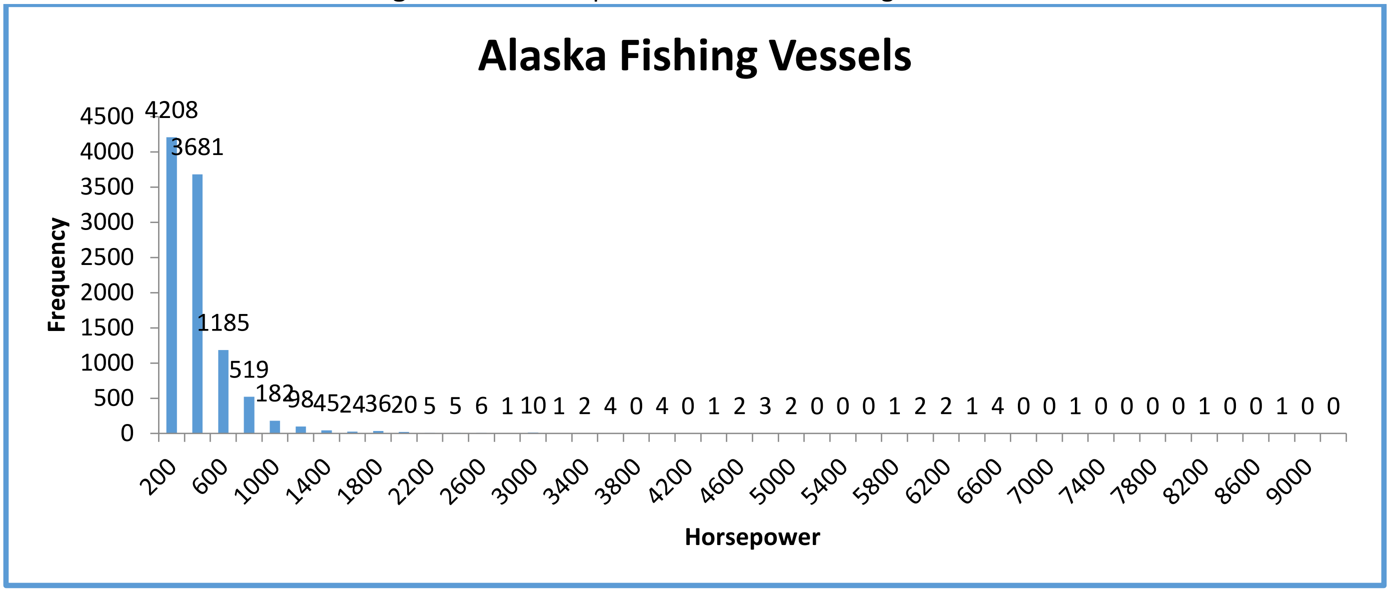
Data obtained from the West Coast regional office [ref 19] were not used in this inventory because the data provided only quantified the number of vessels operating and amount of fish caught by port. Data to quantify hours of operation were not provided. To gap fill the West Coast and the Great Lakes hours of operation, the NOAA website's commercial fishery landings by state [ref 20] were used to calculate a percent change between 2006 and 2013 commercial fish landings in pounds. It should be noted that data for 2014 was not available at the time, so 2013 data were used. Fishing vessel activity values in terms of kW-hours developed in the original Category 1 and 2 Census Study [ref 14] for the West Coast and Great Lakes were extrapolated using the percent change summarized in Table 4-118.

Table 4-118: State fish landing data for Great Lakes and Pacific States

Year (lbs)	Great Lakes					Pacific				
	MI	MN	OH	WI	Total	CA	HI	OR	WA	Total
2006	9,350,764	308,409	4,241,973	4,449,476	18,350,622	341,660,769	26,020,904	282,846,344	241,606,439	892,134,456
2013	9,487,700	457,374	4,812,541	3,850,262	18,607,877	363,798,075	32,447,284	339,589,404	273,796,328	1,009,631,091
Percent Change	1.5	48.3	13.5	-13.5	1.4	6.5	24.7	20.1	13.3	13.2

It is expected that the Alaska fishing vessel activity data would be significant as it represents about half of the U.S. fish landings. But the NOAA data [ref 21] obtained from the Alaska region was problematic as it documented the fleet size to be 2,267 vessels, noting the average duration at-sea per trip was 3 days, but could not provide an estimate of the number of trips these vessels made. Data from the Alaska Commercial Fisheries Entry Commission (CFEC) website which tracked Alaskan fishing vessels for the year 2014 [ref 22] was used to evaluate the state's fishing fleet. The database included build date, horsepower rating, and duration at sea for 10,058 individual vessels. As seen in Figure 4-14, assessing the horsepower of the vessels included in the database revealed that many of the vessels had very small or had no kW ratings. It was uncertain whether these smaller vessels were powered by recreational gasoline marine engines.

Figure 4-14: Horsepower for Alaskan fishing vessels



For this version of the NEI, vessels in the CFEC with a rating of 400 horsepower or less were omitted, leaving 2,169 vessels with horsepower ratings between 402 and 8,800. A study of active commercial Alaskan fishing vessels implemented by the North Pacific Fishery Management Council estimated the commercial fishing vessel fleet operating in state and federal waters around Alaska to be 1,646 unique vessels [ref 23]. Unfortunately, vessel characteristics of the fleet were not included in the report. Therefore, the 2,169 larger vessels identified in the CFEC database were evaluated selecting the largest 1,646 vessels for inclusion into the 2014 NEI.

The days of operation for the vessels in the CFEC database seemed inflated and may indicate potential periods for operation, but not actual periods of operation. For example, many vessels were shown to operate year-round, while most of the regulated fishing seasons in Alaska are restricted to the period from May to September [ref 24], which is about 150 days. The value of 3,600 hours per year (150 days/year x 24 hours = 3,600 hours) was used for Alaska vessels, which may over estimate emissions as it is assumed to be a maximum value for the fishing season. Future versions of the NEI marine vessel inventory should review available AIS data to better quantify Alaskan fishing vessel operations.

For the Northeast and Southeast regions where vessel power was not provided, an average fishing vessel kW power rating (1,000 kW) was obtained from the Category 1 and Category 2 Census [ref 14] to estimate kW-hrs.

For the Alaska regions, horsepower ratings were converted to kW ratings, and applied to the hours of operation to estimate kW-hrs.

Where fishing vessel in-port and underway activities were not distinguished, activity was split to 95% underway and 5% in-port based on the Category 1 and Category 2 Census [ref 14]. Underway activity was also divided between state and federal waters using percentages derived from data on commercial landings of fish and shellfish in the Pacific Ocean for 2013 [ref 20]; landings less than 3 miles from the coast were assumed to be in state waters and landings greater than 3 miles were assumed to be in federal waters. This approach will underestimate some states' activities such as Texas, Florida's Gulf coast, and Puerto Rico where the federal/state water boundary is 9 nautical miles.

It should be noted that additional study of fishing vessel activities is necessary to get a more accurate estimate of the fleet and its vessel characteristics and activity levels in Alaska, Pacific, and Great Lake Areas.

Ferries

The U.S. Department of Transportation's Bureau of Transportation Statistics maintains a database of ferry vessels and activity [ref 26]. This database includes ferry vessels characteristics by operator, trip segment, and terminal information. Individual vessels were linked to operators to develop operator fleet profiles which could be matched to trip segments. The operator fleet profiles included average vessel power and speed. The trip segments did not include travel distance or time information, so GIS tools were used to determine the distance between originating and destination terminals for each segment. During the process, duplicate trip segments were consolidated. Segment travel time was calculated using the segment distances and typical vessel speeds. Each segment had a season start date, as well as a count of trips. Total kW-hrs for each segment that an operator used were calculated using the following equation.

$$\text{kW-hrs} = (D_S / S_V) \times (SL \times [WT_V / 7]) \times kW_V$$

Where:

D_S	=	distance of segment S in nautical miles between the start and end ports
S_V	=	typical speed of vessel V in knots
SL	=	length of the ferry season in days
WT_V	=	number of trips made in a week for vessel V
kW_V	=	kW rating of main engines for vessel V

Offshore oil and gas support vessels:

For the purpose of this inventory, 2011 estimates for the offshore oil and gas support vessels operating in the Gulf of Mexico were obtained from the Bureau of Ocean Energy Management [ref 25]. These vessels include:

- Seismic survey vessels
- Crew boats
- Supply boats
- Drilling rigs
- Anchor handling tugs
- Offshore tugs
- Pipelaying vessels

The 2011 estimates were adjusted to 2014 based on changes in the Gulf of Mexico's annual crude oil production.

4.19.3.4 *Engine operating loads*

Because the activity data used to develop the 2014 NEI did not include engine operating load data or actual vessel speeds, typical operating loads were compiled for each vessel type based on published reports. Initially engine operating load assumptions were taken from the EPA's Current Methodologies in Preparing Port Emission Inventories [ref 27]. This guidance document provided a typical cruising load factor of 0.83. Engine load data from the most recent IMO GHG study [ref 6] were also evaluated. The data in the IMO study included an assessment of bulk carriers, containerships, and tanker speed and engine loads, which accounted for the practice of slow steaming. The IMO data were weighed based on the fleet composition of the E&C data linked up to the IHS vessel characteristics, as provided in Table 4-119.

Table 4-119: IMO underway cruising vessel speed and engine load factors for bulk carriers, containerships, and tankers

Ship Type	Size Category	Size Units	Average at-sea Main Engine Load Factor (% MCR)	Percent of Total Pop.	Engine Load Weight Fraction	Weighted Load Factor
Bulk Carrier	0-9999	dwt	70	0.9	0.0062	0.5893
	10000-34999		59	25.1	0.1480	
	35000-59999		58	36.0	0.2089	
	60000-99999		60	31.7	0.1902	
	100000-199999		57	6.2	0.0353	
	200000+		62	0.1	0.0008	
Container	0-999	TEU	52	4.9	0.0257	0.3672
	1000-1999		45	11.8	0.0531	
	2000-2999		39	12.5	0.0489	
	3000-4999		36	32.8	0.1181	
	5000-7999		32	28.6	0.0915	
	8000-11999		32	9.0	0.0288	
	12000-14500		34	0.3	0.0011	
	14500+		28	0.0	0.0000	
Oil Tanker	0-4999	dwt	67	0.1	0.0009	0.5158
	5000-9999		49	0.3	0.0013	
	10000-19999		49	0.0	0.0000	
	20000-59999		55	3.6	0.0196	
	60000-79999		57	15.6	0.0889	
	80000-11999		51	43.4	0.2212	
	120000-199999		49	32.6	0.1595	
	200000+		54	4.5	0.0244	

dwt = dead weight tonnage; TEU = twenty foot equivalent units

Load factors for RSZ were developed based on vessel speed which was either the maximum speed of the RSZ or the cruising speed of the vessel, which ever value was the smaller. The vessel speed was used in conjunction with the vessel's maximum speed and the propeller rule to estimate the propulsion engine operating load while in the RSZ.

$$LF = (AS/MS)^3$$

Where:

LF = Load Factor (percent)
AS = Actual Speed (knots)
MS = Maximum Speed (knots)

Propulsion engine load factor for maneuvering was assumed to be 0.2, based on Entec's European emission inventory [ref 7]. It is recommended that future versions of this inventory consider reviewing AIS in port data to more accurately quantify maneuvering loads. It was also assumed that the auxiliary engines would be operating during maneuvering based on EPA port guidance [ref 27] as summarized in Table 4-120.

Table 4-120: Auxiliary operating loads

Vessel Types	Maneuver	Hotel
Bulk Carrier	0.45	0.1

Vessel Types	Maneuver	Hotel
Bulk Carrier, Laker	0.45	0.1
Buoy Tender	0.45	0.22
Container	0.48	0.19
Crude Oil Tanker	0.33	0.26
Drilling	0.45	0.22
Fishing	0.45	0.22
FPSO	0.45	0.22
General Cargo	0.45	0.22
Icebreaker	0.45	0.22
Jackup	0.45	0.22
LNG Tanker	0.33	0.26
LPG Tanker	0.33	0.26
Misc.	0.45	0.22
Passenger	0.8	0.64
Pipelaying	0.45	0.22
Reefer	0.67	0.32
Research	0.45	0.22
RORO	0.45	0.26
Supply	0.45	0.22
Support	0.45	0.22
Tanker	0.33	0.26
Tug	0.45	0.22
Vehicle Carrier	0.45	0.22
Well Stimulation	0.45	0.22

While the vessel is dockside, it was assumed that propulsion engines would not be operating and the auxiliary engines were operating at the loads noted in Table 4-120. For vessels equipped with C 1 and C2 propulsion engines it was assumed that neither the propulsion nor the auxiliary engines would be operating while dockside to conserve fuel. This version of the NEI also did not include activity or emissions associated with boilers used to generate steam or to run cargo handling equipment and pumps.

4.19.3.5 *Emission factors and HAP speciation profiles*

Vessels equipped with Category 3 propulsion engines

As the dominant propulsion engine configuration for large Category 3 vessels is the slow speed diesel (SSD) engine, the following SSD emission factors were used for Category 3 propulsion engines. Medium speed diesel (MSD) emission factors were used for auxiliary engines associated with these larger vessels. For the 2014 inventory, it was assumed that Emission Control Area (ECA) compliant fuels were used while transiting U.S. waters. Emission factors for vessels equipped with Category 3 propulsion engines [ref 28] are presented in Table 4-121.

Table 4-121: Category 3 emission factors (g/kW-hours)

Type	Engine	Fuel	NO_X	VOC_a	HC	CO	SO_2	CO_2	PM_{10}	$PM_{2.5\ b}$
SSD	Main	1% Sulfur	14.7	0.6318	0.6	1.4	3.62	588.86	0.45	0.42
MSD	Aux	1% Sulfur	12.1	0.4212	0.4	1.1	3.91	636.6	0.47	0.43

From: U.S. EPA/OTAQ, Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder, March 2008 [ref 28].

[a] Hydrocarbon (HC) was converted to VOC using a conversion factor of 1.053 as provided in [ref 28]
[b] $PM_{2.5}$ was assumed to be 97 percent of PM_{10} using [ref 28]

Note that this approach assumes that all large vessels will implement fuel switching before 2014 to comply with the 1% fuel sulfur standard, and use of controls such as scrubbing of high sulfur fuels, which is also an option to meet regulations, will be minimal.

If an engine load factor is less than 20 percent of the engine operating load, the emission factors were adjusted to account for operations outside the engines typical optimal load. For this 2014 inventory, these low load periods tend to occur during vessel movements in the RSZ. The low load adjustment factors used in this inventory were obtained from the EPA port guidance [ref 27] and are provided in Table 4-122.

Table 4-122: Calculated low load multiplicative adjustment factors

Load	NO_x	HC	CO	PM	SO_2	CO_2
1%	11.47	59.28	19.32	19.17	5.99	5.82
2%	4.63	21.18	9.68	7.29	3.36	3.28
3%	2.92	11.68	6.46	4.33	2.49	2.44
4%	2.21	7.71	4.86	3.09	2.05	2.01
5%	1.83	5.61	3.89	2.44	1.79	1.76
6%	1.60	4.35	3.25	2.04	1.61	1.59
7%	1.45	3.52	2.79	1.79	1.49	1.47
8%	1.35	2.95	2.45	1.61	1.39	1.38
9%	1.27	2.52	2.18	1.48	1.32	1.31
10%	1.22	2.20	1.96	1.38	1.26	1.25
11%	1.17	1.96	1.79	1.30	1.21	1.21
12%	1.14	1.76	1.64	1.24	1.18	1.17
13%	1.11	1.60	1.52	1.19	1.14	1.14
14%	1.08	1.47	1.41	1.15	1.11	1.11
15%	1.06	1.36	1.32	1.11	1.09	1.08
16%	1.05	1.26	1.24	1.08	1.07	1.06
17%	1.03	1.18	1.17	1.06	1.05	1.04
18%	1.02	1.11	1.11	1.04	1.03	1.03
19%	1.01	1.05	1.05	1.02	1.01	1.01
20%	1.00	1.00	1.00	1.00	1.00	1.00

Vessels equipped with Category 1 / Category 2 propulsion engine

Activity data for smaller vessels equipped with C1 and C2 engines are aggregated together, therefore Category 2 emission factors (Table 4-123) were used for these vessels as these factors tended to provide more conservative emission estimates.

Table 4-123: Tier emission factors for vessels equipped with Category 2 propulsion engines (g/kW-hours)

Tier	PM_{10}	NO_x	HC	CO	VOC [a]	PM_{25} [b]	SO_2	CO_2
0	0.32	13.36	0.134	2.48	0.141102	0.3104	0.006	648.16
1	0.32	10.55	0.134	2.48	0.141102	0.3104	0.006	648.16
2	0.32	8.33	0.134	2.00	0.141102	0.3104	0.006	648.16
3	0.11	5.97	0.07	2.00	0.073710	0.1067	0.006	648.16

From: U.S. EPA/OTAQ, Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters per Cylinder, March 2008 [ref 28].

[a] HC was converted to VOC using a conversion factor of 1.053 as provided in the above reference.

[b] $PM_{2.5}$ was assumed to be 97 percent of PM_{10} using the above reference.

The Tier emission factors noted in Table 4-124 were weighted relative to the vessel type based on the year the vessel was manufactured. Table 4-125 shows the vessel age distribution by Tier.

Table 4-124: Vessel tier population by type for vessels equipped with C1 or C2 propulsion engines

Trip Count	Vessel Count	Vessel Type	Total*	Tier Level				Percent Tier			
				0	1	2	3	0	1	2	3
5,330	51	Bulk Carrier	51	46		5		90.2	0	9.8	0
932	23	Bulk Carrier, Laker	23	23				100	0	0	0
5	3	Buoy Tender	3	3				100	0	0	0
200	2	Container	2	2				100	0	0	0
2,421	25	Containership	25	22	3			88	12	0	0
140,767	426	Crewboat / Supply / Utility Vessel	425	298	37	87	3	70.1	8.7	20.5	0.7
7	5	Drilling	5	2		3		40	0	60	0
19,026	13	Excursion / Sightseeing Vessel	13	12		1		92.3	0	7.7	0
276	45	Fishing	45	43	2			95.6	4.4	0	0
29,660	153	General Cargo	152	93	11	48		61.2	7.2	31.6	0
8	2	Icebreaker	2	2				100	0	0	0
10	3	Jackup	3	2		1		66.7	0	33.3	0
8	2	LPG Tanker	2			2		0	0	100	0
247,369	35	Misc.	33	28	2	3		84.8	6.1	9.1	0
749	26	Passenger	26	24	1	1		92.3	3.8	3.8	0
4,666	18	Passenger Carrier	18	15	3			83.3	16.7	0	0
61	10	Pipelaying	10	10				100	0	0	0
344,540	1,626	Pushboat	1,625	1,348	43	214	20	83	2.6	13.2	1.2
63	12	Reefer	12	12				100	0	0	0
346	42	Research	42	35	1	6		83.3	2.4	14.3	0
1,771	19	RORO	19	17	1	1		89.5	5.3	5.3	0
230	3	RO-RO Vessel	3	3				100	0	0	0
4,778	243	Supply	243	126	31	86		51.9	12.8	35.4	0
808	66	Support	66	28	7	31		42.4	10.6	47	0

Table 4-125: Vessel tier population by type for vessels equipped with C1 or C2 propulsion engines

Trip Count	Vessel Count	Vessel Type	Total*	Tier Level				Percent Tier			
				0	1	2	3	0	1	2	3
5553	102	Tanker	101	47	11	43		46.5	10.9	42.6	0
3962	336	Tug	336	286	13	35	2	85.1	3.9	10.4	0.6
14251	867	Tugboat	867	630	48	172	17	72.7	5.5	19.8	2
2	1	Well Stimulation	1	1				100	0	0	0
95606	4159	Total / Average Percent Tier	4,153	3,158	214	739	42	76	5.2	17.8	1

Note this approach does not account for early introduction of controls by vessel operators, compliance with more stringent local standards, or participation in voluntary emission reduction programs such as California's Carl Moyer Program or the Texas Emission Reduction Plan (TERP).

Hazardous air pollutant emissions were estimated by applying speciation profiles (Appendix F, ref 4) to the VOC estimates for organic HAPs and PM estimates for metal HAPs using the following equation:

$$E = A \times SF$$

Where:

E	=	Annual emissions for HAP (tons)
A	=	Annual emissions for speciation base (tons)
SF	=	Speciation factor (unit less fraction)

Emission Summaries

Based on the approach documented above, Table 4-126 summarizes activity and emissions by vessel propulsion engine category and mode. Table 4-127 also summaries emissions by vessel type.

Table 4-126: 2014 EPA-estimated vessel activity (kW-hrs) and emissions (tons) by propulsion engine and mode

Category	Source	SCC	Mode	Total Activity (kW-hr)	NO_X	PM_{10}	PM_{25}	SO_2	VOC
Cat1/2	E&C	2280002100	Maneuvering	742,228,543	1,179	44	40	333	39
Cat1/2	E&C	2280002200	Cruising	945,222,365	9,648	255	247	5	113
Cat1/2	Misc-C1/C2	2280002100	Maneuvering	4,086,763,051	11,316	285	276	5	126
Cat1/2	Misc-C1/C2	2280002200	Cruising	13,348,660,561	336,909	10,409	10,097	2,258	5,785
Cat1/2	WBD	2280002100	Maneuvering	2,090,680,129	5,754	147	143	3	65
Cat1/2	WBD	2280002200	Cruising	19,795,947,087	196,657	5,049	4,898	94	2,228
Cat3	E&C	2280003100	Dock	27,735,673,393	39,098	1,540	1,409	12,665	1,503
Cat3	E&C	2280003100	Maneuvering	7,217,499,394	6,568	216	200	1,758	267
Cat3	E&C	2280003200	Cruising	64,474,040,733	586,555	17,956	16,759	144,444	25,210
Cat3	E&C	2280003200	Reduced Speed Zone	7,055,981,077	22,034	713	666	5,492	1,319
			Total	**147,492,696,332**	**1,215,718**	**36,614**	**34,735**	**167,058**	**36,654**

Note: Misc C1/C2 includes: Coast Guard, dredging, ferries, fishing, offshore oil & gas support, and research.

Table 4-127: 2014 EPA CMV emissions by vessel type

Vessel Type	Total Activity (kW-hr)	NO_X	PM_{10}	PM_{25}	SO_2	VOC
Bulk Carrier	16,502,188,704	108,528	3,278	3,070	23,396	4,264
Bulk Carrier, Laker	591,085,436	4,349	129	121	865	161
Buoy Tender	2,647,731	32	1	1	0	0
Coast Guard	2,150,964,635	26,292	630	611	12	278
Containership	53,193,329,151	220,943	6,808	6,359	50,912	9,048
Dredging	1,041,726,442	12,273	294	285	5	130
Excursion / Sightseeing Vessel	4,319,972	50	1	1	0	1

Vessel Type	Total Activity (kW-hr)	NO_X	PM_{10}	PM_{25}	SO_2	VOC
Ferries	5,641,357,376	32,678	825	800	16	365
Fishing	6,585,566,278	76,606	1,852	1,797	34	817
General Cargo	4,462,901,347	36,436	1,126	1,052	8,522	1,472
Miscellaneous	1,101,196,066	4,247	108	105	53	53
Offshore Oil & Gas*	669,380,168	182,540	6,653	6,454	2,188	4,128
Passenger	11,886,827,285	123,561	3,835	3,576	30,586	5,254
Reefer	1,082,375,467	9,645	303	282	2,425	406
Research	2,015,808,882	22,507	573	556	11	253
RO-RO	2,369,916,464	20,995	574	547	1,998	469
Tanker, Crude Oil	7,192,697,038	42,670	1,329	1,238	10,710	1,819
Tanker, LNG/LPG	1,461,972,434	13,291	412	384	3,314	567
Tanker, Miscellaneous	14,088,889,926	121,580	3,725	3,508	22,470	4,221
Tug	11,197,514,271	119,306	3,005	2,913	250	1,343
Vehicle Carrier	4,250,031,261	37,187	1,154	1,076	9,291	1,608
Total	**147,492,696,332**	**1,215,718**	**36,614**	**34,735**	**167,058**	**36,654**

* Note: Some Offshore Oil & Gas emissions were derived from the BOEM Emission Inventory which did not include activity data.

4.19.3.6 *Allocation of port and underway emissions*

Ports and underway activity and emissions are summarized in Table 4-128. Note that in this version of the marine vessel component of the NEI, auxiliary emissions for underway operations were considered less significant than other modes and were not included in this version of the NEI marine vessel inventory, such that actual underway emissions may be slightly higher than the values presented in Table 4-128.

Table 4-128: 2014 vessel activity (kW-hrs) and EPA emissions (tons) by propulsion engine and SCC

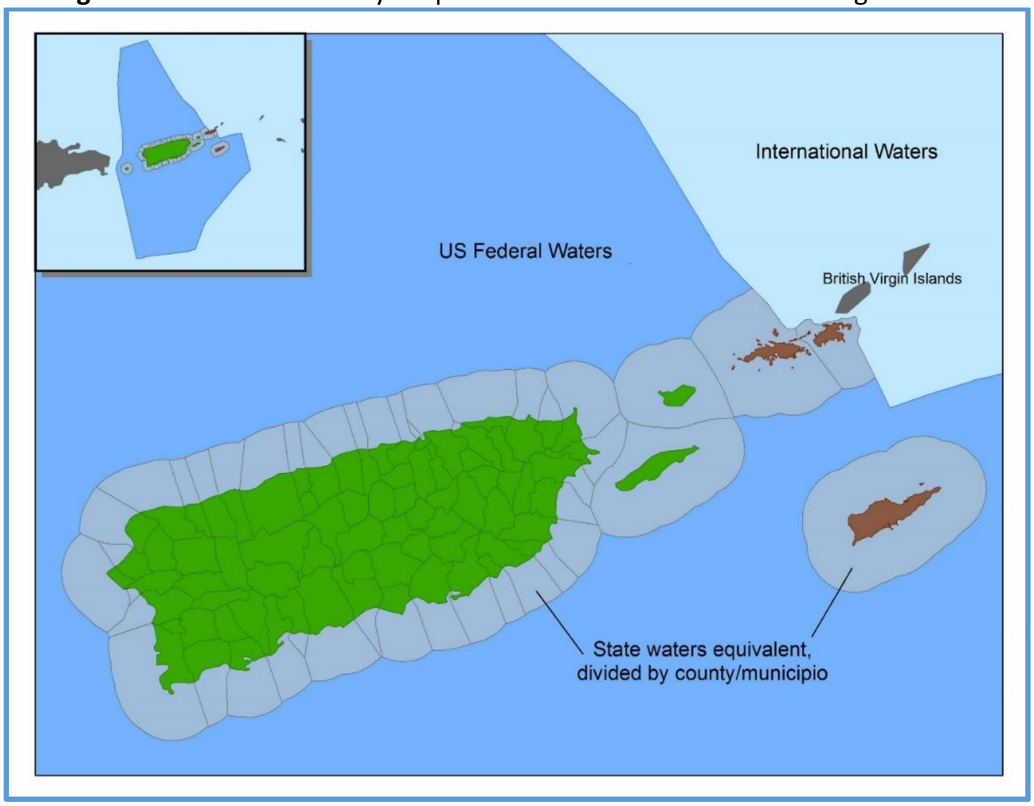
SCC Description	SCC	Total Activity (kW-hr)	NO_X	PM_{10}	PM_{25}	SO_2	VOC
Diesel Port	2280002100	6,919,671,722	18,250	476	459	341	230
Diesel Underway	2280002200	34,089,830,013	543,214	15,713	15,242	2,357	8,125
Residual Port	2280003100	34,953,172,787	45,666	1,756	1,609	14,423	1,770
Residual Underway	2280003200	71,530,021,810	608,589	18,669	17,425	149,936	26,529
Total		**147,492,696,332**	**1,215,718**	**36,614**	**34,735**	**167,058**	**36,654**

EPA has continued to develop and improve port shapes using a variety of resources. First, GIS data or maps provided directly from the ports were used to delineate port boundaries. Next, maps or port descriptions from local port authorities and port districts were used in combination with existing GIS data to identify port boundaries. Finally, satellite imagery from tools such as Google Earth and street layers from StreetMap USA were used to delineate port areas. Originally, primary emphasis was placed on mapping the 117 ports with C3 vessel activity using available shapefiles of the port area. As the availability of C1 and C2 activity improved, additional port shapes were required to represent their emissions. The NEI port shapefiles were revised to include 114 additional ports from the 2014 inventory. Further revisions over the years have increased the count of the current 5,649 port shapes for the 2014v1 inventory. 2014v2 revisions reduced the number of port shapes dramatically, to 915.

In all cases, port shapes were split by county boundary, such that no shape crosses county lines, to facilitate totaling of emissions to the state or county level. Each port shape was identified by the port name and state and county FIPS in addition to a unique Shape ID. In most cases, port shapes were created on land bordering waterways and coastal areas. However, the additional port shapes created in this effort were generated as small circles with a radius of 0.25 miles that cover both land and water. Additionally, activity data such as Automatic Identification System (AIS) indicated that vessels frequently have maneuvering/hoteling activities further offshore than previously anticipated. As such, the underway shapes were duplicated, given new IDs, and added to the port shapefile to provide a place to put these activities if state or local agencies wish to include them.

Underway shapes remain unchanged with the exception of new shapes added to represent state and federal waters around Puerto Rico and the U.S. Virgin Islands as shown in Figure 4-15.

Figure 4-15: New underway shapes for Puerto Rico and the U.S. Virgin Islands



Spatial allocation of the activity data varied by data source. Port activity was allocated to the origin and destination port shapes. E&C data and the WCD were routed along a waterway network, then the routes were intersected with EPA's shapefiles shipping lanes for NEI. For the E&C data, underway activity for each vessel trip was divided among the NEI shapes based on the portion of the route that passed through each shape. The length of the waterway segment passing through each shape was divided by the total trip length to calculate the percentage of the trip's activity to assign to each shape.

$$V = (L/T) * A$$

Where:

V = Activity for shape V
L = Length of waterway segment within shape V
T = Total trip length

A = Total trip activity

For WCD, hoteling and maneuvering activity was allocated to the nearest water-based port shapes for each origin and destination. For underway activity, the length of the waterway through each shape was calculated and multiplied by the number of trips in that shape. This value was divided by the national total for trips multiplied by length to determine the percentage of the national total activity to allocate to each shape.

$$P = (T * L)/(NT*NL)$$

Where:

P = Percentage of national activity
T = Total trips for the NEI underway shape
L = Waterway segment length within underway shape
NT = National trip total
LN = National waterway network length total

Offshore oil and gas support vessel data derived from AIS data used by BOEM was limited to federal waters and was assigned to the associated shape, though the more refined activity can be seen in Figure 4-16. Research vessel activity was allocated to shapes based on the spatial allocation from the Category 1 and Category 2 Census [ref 14]. Dredging activities were spatially apportioned to ship channels based on the job name. The job names indicated general location, such as a bay area or a waterway portion; however, they did not provide sufficient information to precisely locate the dredging activities or even extent of the project. Best effort was given to identify the waterway segments in GIS that most closely match the limited location information. Ferry activity was split to 65% port and 35% underway, and all terminals were mapped using the coordinates available in the National Census of Ferry Operators [ref 26]. Activity was then allocated to the port or underway shape nearest each ferry terminal. The underway spatial allocation can be seen in Figure 4-17. U.S. Coast Guard activity was provided by region, NEI shapes in each region were identified, and underway activity was allocated to individual shapes as a fraction of the total region's area as shown in Figure 4-18.

Figure 4-16: Spatial allocation of 2014 support vessel activity

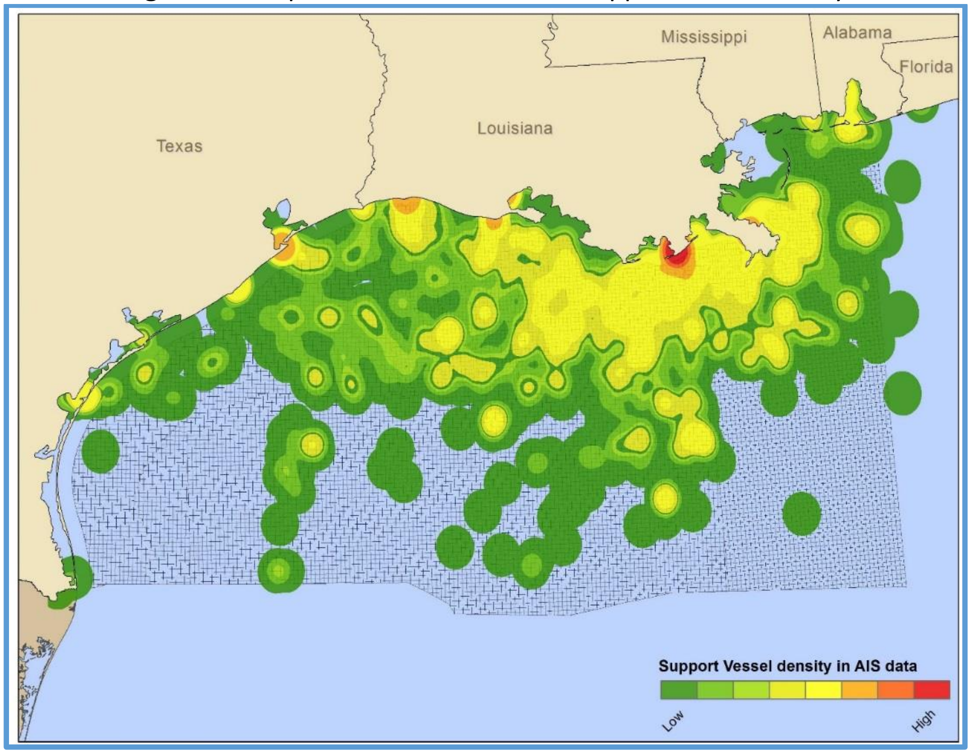


Figure 4-17: Spatial allocation of 2014 ferry activity

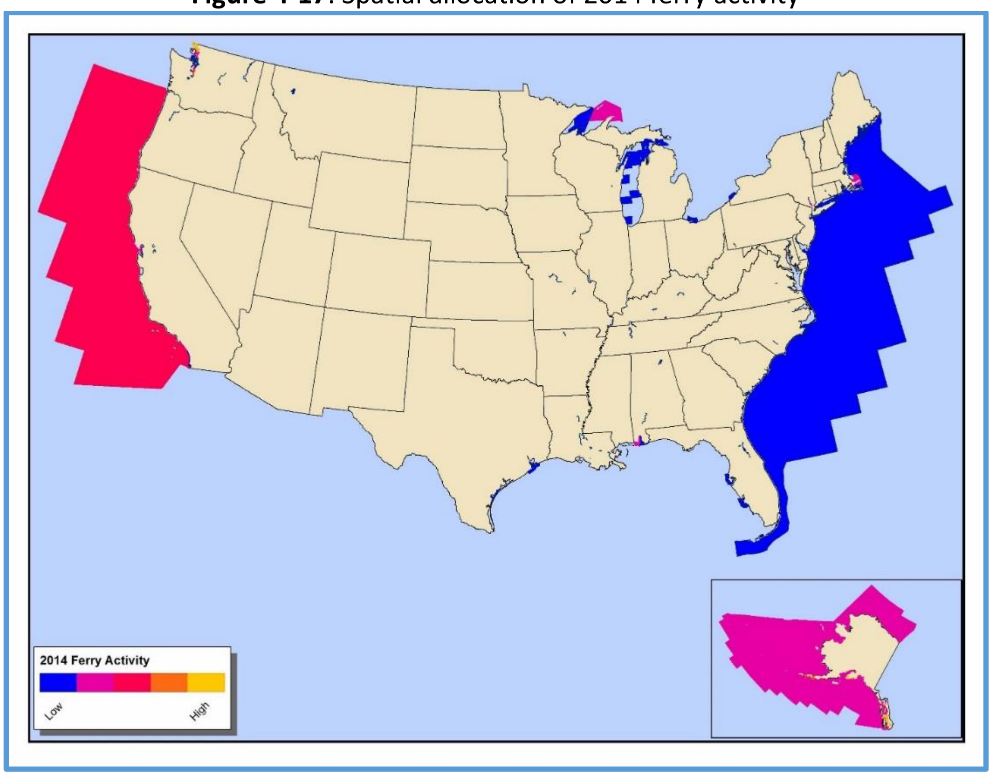
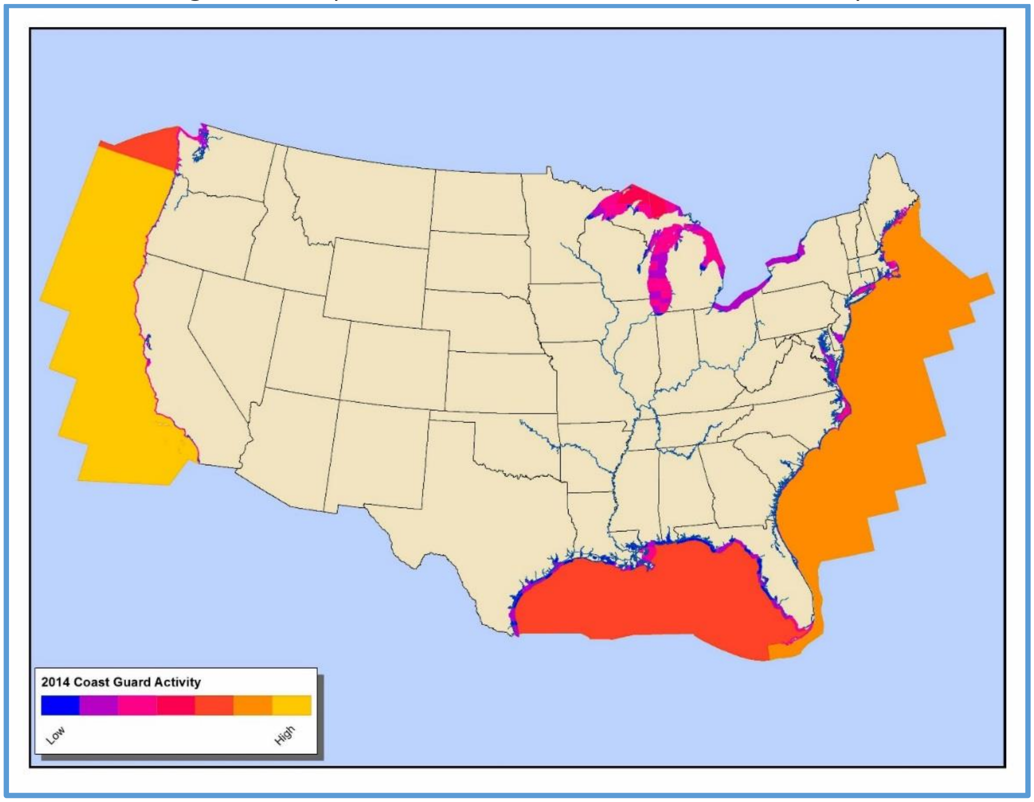


Figure 4-18: Spatial allocation of 2014 Coast Guard activity



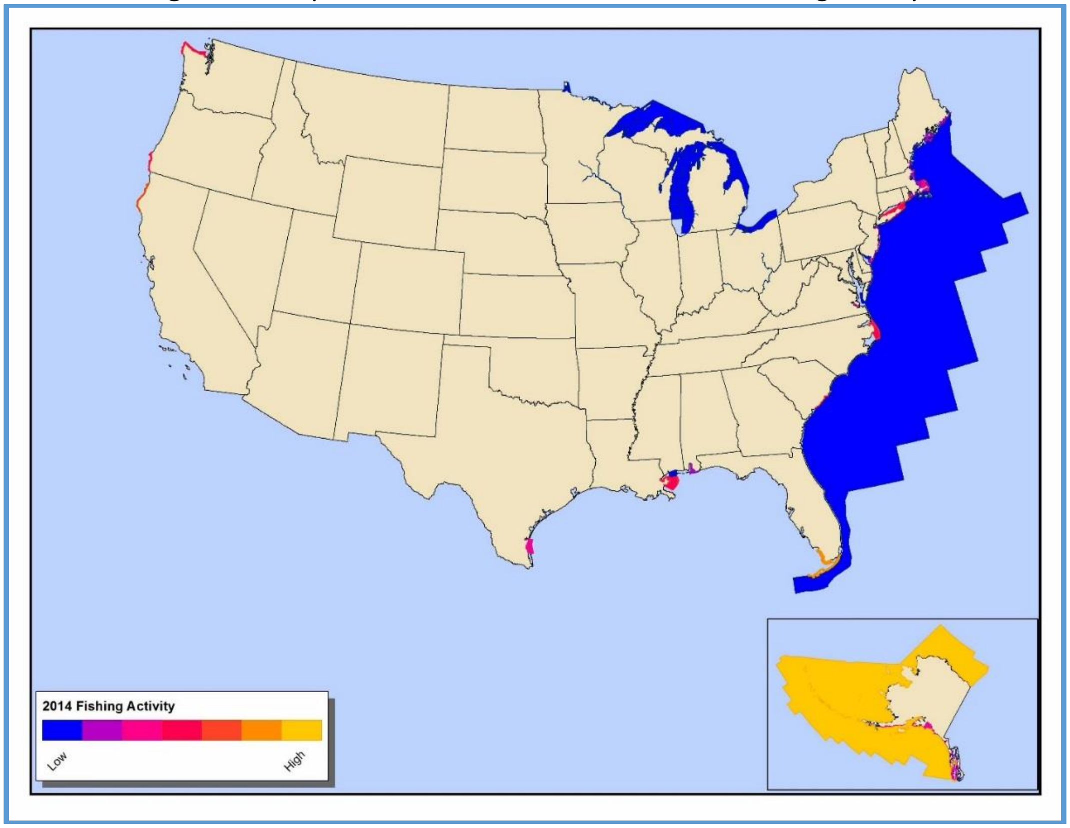
Fishing vessel activity was spatially allocated using different methods based on available regional data. Alaska fishing activity was spatially apportioned based on NOAA data that listed the number of catcher vessels by region for the Aleutian Islands, Western Alaska, Central Gulf of Alaska, and Eastern Gulf of Alaska as shown in Table 4-129. The NEI shapes were assigned to these regions in GIS, and then emissions were spatially allocated by region based on shape area.

Table 4-129: Alaska commercial fishing catcher vessel count

Area	Catcher Vessels	Percent
Aleutian Islands	494	23
Western Alaska	64	3
Central Gulf of Alaska	728	34
Eastern Gulf of Alaska	854	40

The Northeast NOAA data provided fishing activity by city or by state [ref 17]. Cities were mapped, and activity values were assigned to the nearest port and underway shape ID. In some cases, the city name was unknown, so the activity was divided between other known ports within that state proportionate to their activity values. For the southeast and the west coast, total activity was provided by state. Statewide activity was divided as 95% underway and 5% in-port and then allocated to shapes based on the previous fishing allocation in the Category 1 and Category 2 Census [ref 14]. The final fishing allocation can be seen in Figure 4-19.

Figure 4-19: Spatial allocation of 2014 commercial fishing activity



4.19.3.7 *Summary of quality assurance methods for EPA-developed emissions*

- While developing the EPA 2014 marine vessel inventory, data quality checks were implemented at critical points; this included comparison with earlier data sets used to develop the C1 and C2 inventory, published emission factors, and previous NEI emission estimates for all engine categories.
- All calculations were checked by experience staff members of the team.
- During data transfers into the project database, quality assurance checks were implemented and data summary tables generated to ensure that no corrupted data were transferred and the record count was consistent with the transfer.
- All assumptions were documented and discussed with team members to ensure that the assumptions were reasonable and consistent with other known data points.
- Microsoft Access data queries were documented and reviewed by experience staff who were not directly involved in developing the current databases.
- GIS imagery were reviewed to identify any spatial anomalies in the data.
- Where anomalies were found during these checks, additional research was implemented to determine whether the identified issue was correct or whether there was an error in developing the estimate.

EPA compared shape-, state-, and county-level sums in (1) EPA default data, (2) state/local/tribal (S/L/T) agency submittals, and (3) the resultant 2011 NEI selection by:

- Pollutants, SCCs, and SCC-emission types
- Emissions summed to agency and SCC level.

4.19.4 Known Issue: County FIPS error in Alaska

The new port shapes developed for the 2014v2 NEI erroneously included three Alaska county FIP codes which are no longer valid due to county FIP changes made prior to 2014. The error was not corrected. No emissions were lost, but data users should be cautioned that county sums in Alaska will not be accurate. Table 4-130 below summarizes the correct FIPs for each CMV shape and the magnitude of CMV NOx emissions sums that should have been reallocated to the corrected county. This error will be remedied in the 2017 NEI.

Table 4-130: County FIPs Corrections for Alaska CMV Shape Emissions

Retired FIPs	Revised FIPs	Shape ID	CMV Nox 2014v2
02201	02198	20598	0.96
02201	02198	20602	0.91
02201	02198	20603	0.91
02201	02275	20604	0.92
02201	02198	20605	0.91
02201	02198	20619	2.27
02232	02105	20190	191.34
02232	02105	20191	110.11
02232	02105	20192	80.59
02232	02230	20336	238.76
02232	02105	20601	0.91
02232	02105	20837	50.48
02280	02198	20171	878.68
02280	02195	20539	2.50
02280	02275	20599	1.85

4.19.5 Summary of quality assurance between EPA and S/L/T submittals

Submitted EPA estimates were compared to EPA's. These checks were performed:

- Shape files used. Because CMV estimates must be allocated to port and underway GIS polygons (shape files), it was important to check for potentially erroneous double counting where EPA and states used different shapes. Where necessary, EPA estimates were tagged, for example in Texas where the state provided all emissions to be included in the NEI. In other areas, like Washington, only certain ports had been studied and provided and thus EPA estimates in other areas were used.
- Reasonableness comparisons of pollutant totals. This check led to replacing California's provided HAPs with EPA-augmented ones.
- Individual pollutants compared to pollutant groups to avoid including both.
- Where HAPs were not submitted, HAP-Aug was applied to estimate HAPs from submitted criteria pollutants.
- Chromium compounds were split into hex- and tri-valent chromium.
- Missing criteria estimates. This check found that California did not provide NH_3 for all processes. In these cases, EPA NH3 records are used in the NEI if they exist for the same processes.

4.19.6 References for commercial marine vessels

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4.20 Mobile - Locomotives (Nonpoint)

This section documents locomotives (rail) emissions in the nonpoint data category. For information on rail yard emissions in the point data category, refer to Section 3.3.

4.20.1 Sector description

The locomotive sector includes railroad locomotives powered by diesel-electric engines. A diesel-electric locomotive uses 2-stroke or 4-stroke diesel engines and an alternator or a generator to produce the electricity required to power its traction motors. The locomotive source category is further divided up into categories: Class I line haul, Class II/III line haul, Passenger, Commuter, and Yard. Table 4-131 below indicates locomotive SCCs and whether EPA estimated emissions. If EPA did not estimate the emissions, then all emissions from that SCC that appear in the inventory are from S/L/T agencies.

Table 4-131: Locomotives SCCs, descriptions and EPA estimation status

SCC	Description	EPA Estimated?	Data Category
2285002006	Mobile Sources; Railroad Equipment; Diesel; Line Haul Locomotives: Class I Operations	Yes – in shape files	Nonpoint
2285002007	Mobile Sources; Railroad Equipment; Diesel; Line Haul Locomotives: Class II / III Operations	Yes-in shape files	Nonpoint
2285002008	Mobile Sources; Railroad Equipment; Diesel; Line Haul Locomotives: Passenger Trains (Amtrak)	No	Nonpoint
2285002009	Mobile Sources; Railroad Equipment; Diesel; Line Haul Locomotives: Commuter Lines	No	Nonpoint
2285002010	Mobile Sources; Railroad Equipment; Diesel; Yard Locomotives	No	Nonpoint
28500201	Internal Combustion Engines; Railroad Equipment; Diesel; Yard Locomotives	Yes – as point sources	Point

4.20.2 Sources of data

The nonpoint component of this source category includes data from the S/L/T agency submitted data and the default EPA generated emissions. The state agencies listed Table 4-132 in submitted at least $PM_{2.5}$, NO_X and VOC emissions for the indicated SCCs; agencies not listed used EPA estimates for all nonpoint rail.

Table 4-132: Source Category Codes with emissions submitted by reporting agency

Region	Agency	S/L/T	2285002006	2285002007	2285002008	2285002009	2285002010
1	Massachusetts Department of Environmental Protection	State				X	
3	Maryland Department of the Environment	State	X	X	X	X	
3	Virginia Department of Environmental Quality	State			X	X	
4	North Carolina Department of Environment and Natural Resources	State			X		
6	Texas Commission on Environmental Quality	State	X	X			
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	X				
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	Tribe	X				
9	California Air Resources Board	State	X	X	X	X	X
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	Tribe	X				
9	Washoe County Health District	Local	X				
10	Alaska Department of Environmental Conservation	State				X	
10	Washington State Department of Ecology	State	X		X		X

4.20.3 EPA-developed emissions for nonpoint locomotives: new for 2014v2 NEI

All EPA estimates used in the 2014v1 NEI were replaced for the 2014v2 NEI. Shapes (links) used in 2014v1 were abandoned and 2014v2 estimates are at the county-level.

EPA used emissions estimates developed by the Eastern Regional Technical Advisory Committee's (ERTAC) rail group. The group coordinated with the Federal Rail Administration to collect link-based activity data and apply the equipment-specific emission factors appropriate. Their report on this work is available in the document "Railv2_3ERTAC_Rail_2014_Inventory_Documentation_20170220.pdf" on the2014v2 Supplemental Rail and CMV Data FTP site.

4.20.3.1 *Hazardous Air Pollutant Emissions Estimates*

HAP emissions were estimated by applying speciation profiles to the VOC or PM estimates. Because California uses low sulfur diesel fuel and emission factors specific for California railroad fuels were available, calculations of California's emissions were done separately from the other reporting agencies. HAP estimates were calculated at the yard and link level, after the criteria emissions had been allocated. Where submitting agencies did not supply HAPs, those estimates were also derived via this VOC/PM speciation method. EPA's HAP speciation factors are available in the spreadsheet "Railv2_4HapSpeciation_20170220.xlsx" on the2014v2 Supplemental Rail and CMV Data FTP site.

4.20.4 Summary of quality assurance

EPA and S/L/T agency-submitted values were compared to find instances where:

- Point and nonpoint rail yard SCCs may duplicate. This occurs when agencies submitted nonpoint in the same counties where EPA had point yards. In this case, EPA point yard records were tagged.
- Different variations of the same pollutant were used by agencies and EPA. For instance, individual xylenes versus mixed xylene compounds. When agencies submitted total chromium, the value was apportioned to hex- and trivalent chromium.
- Suspiciously high or low emissions. As advised by California, all CA HAPs were tagged and EPA values used instead.

4.21 Solvent – Consumer & Commercial Solvent Use: Agricultural Pesticides

There are three sections in this documentation that discuss nonpoint sources of Consumer and Commercial Solvent Use. This section discusses agricultural pesticides; the following section discusses asphalt paving, and the third section discusses all other Solvent sources, including the remaining sources in the Consumer and Commercial Solvent Use sector. The reason these sources are broken up within this EIS sector is because the EPA methodologies for estimating the emissions are different.

4.21.1 Source category description

While Agricultural Pesticide Application is part of Consumer and Commercial Solvents sector, the nature of its methodology is significantly different from most of the other sources in this sector. Pesticides are substances used to control nuisance species and can be classified by targeted pest group: weeds (herbicides), insects (insecticides), fungi (fungicides), and rodents (rodenticides). They can be further described by their chemical characteristics: synthetics, non-synthetics (petroleum products), and inorganics. Different pesticides are made through various combinations of the pest-killing material, also called the active ingredient (AI), and various solvents (which serve as carriers for the AI). Both types of ingredients contain volatile organic compounds (VOC) that may be emitted to the air during application or after application because of evaporation [ref 1].

4.21.2 Sources of data

As seen in Table 4-133, this source category includes data from the S/L/T agency submitted data and the default EPA generated emissions. EPA estimates emissions for only Agricultural application (SCC=2461850000). New Jersey and Maryland also reported emissions for Surface Application (2461800001) and Maryland also reported estimates for Soil Incorporation (2461800002). The leading SCC description is “Solvent Utilization; Miscellaneous Non-industrial: Commercial” for all SCCs.

Table 4-133: Agricultural Pesticide Application SCCs estimated by EPA and S/L/Ts

SCC	Description	EPA	State	Local	Tribe
2461800001	Pesticide Application: All Processes; Surface Application		X		
2461800002	Pesticide Application: All Processes; Soil Incorporation		X		
2461850000	Pesticide Application: Agricultural; All Processes	X	X		X

The agencies listed in Table 4-134 submitted 100% of their VOC emissions for agricultural pesticide application; agencies not listed used EPA estimates for the entire sector.

Table 4-134: Percentage of Agricultural Pesticide Application VOC emissions submitted by reporting agency

Region	Agency	S/L/T	VOC
1	New Hampshire Department of Environmental Services	State	100
2	New Jersey Department of Environment Protection	State	100
3	Delaware Department of Natural Resources and Environmental Control	State	100
5	Illinois Environmental Protection Agency	State	100
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	100
9	California Air Resources Board	State	100
10	Coeur d'Alene Tribe	Tribe	100
10	Idaho Department of Environmental Quality	State	100
10	Kootenai Tribe of Idaho	Tribe	100
10	Nez Perce Tribe	Tribe	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100

4.21.3 EPA-developed emissions for agricultural pesticide application

This is the first time that EPA has provided estimates for this source category; therefore, these emissions are new for the 2014 NEI, and were not covered on a national basis for previous inventory years. Members of the NOMAD Committee (Idaho and Texas) were instrumental in developing this methodology. An inventory developer in Idaho developed the method, based on one used in Idaho for many years. An inventory developer from TCEQ (TX) then created a tool in MS Access, and also provided instructions, which makes the method easy to use for all reporting agencies.

Approximately 68 to 75 percent of pesticides used in the United States are applied to agricultural lands, both cropland and pasture. Agricultural pesticides continue to be a cost-effective means of controlling weeds, insects, and other threats to the quality and yield of food production. Since application rates for a particular pesticide may vary from region to region, the regional application rates should be considered when estimating potential VOC emissions.

4.21.3.1 *Emission factors*

The VOC emission factor is derived for each active ingredient based on the pesticide profiles database maintained by the California Department of Pesticide Regulation [ref 2]. The California Department of Pesticide Regulation's (CA DPR) database contains the chemical formulation for pesticides registered in the State of California and provides key inputs for the development of VOC emission factors. These key inputs include mass fraction of each active ingredient and the emission potential (EP) of registered pesticide products. The EP value represents the VOC content of the pesticide product and it is determined empirically through thermogravimetric analysis (TGA). Because the CA DPR database lists both agricultural and non-agricultural pesticide products, it was necessary to screen out entries that were likely formulated as a consumer product. Pesticide products that contained terms suggesting non-agricultural applications were excluded. Terms used to screen out likely consumer products are listed in Table 4-135.

Table 4-135: Terms used to screen out consumer products

ALGAE	DEODORIZING	GERM	MRSA	STAIN
ANT	DETERGENT	HAMSTER	ORNAMENTAL	SWIM
BATHROOM	DISHWASHER	HOME	POND	TICK
BEDBUG	DISINFECT	HORNET	POTTY	TURF

BEE	DOG	HORSE	PRESCRIPTION	WASP
CAT	DRAIN	HOUSE	RAT	WIPES
CATTLE	EQUINE	INDOOR	ROACH	YARD
CLEANER	FLEA	KLEEN	RODENTICIDE	
DECK	FLY	LANDSCAPE	ROOF	
DEGREASER	FOGGER	LAWN	SANI	
DEODORIZER	GERBIL	MOUSE	SPA	

Each record in the DPR database is for a specific pesticide product, and provides product name, primary active ingredient, the mass percent of active ingredient, emission potential (EP), registration number, and method used to estimate the EP. The pesticide specific EP of reactive organic gases (i.e., the mass percentage of product that contributes to VOC emissions) and the mass percent of active ingredient were used to calculate pesticide-specific VOC emission factors.

$$EF_{pesticide} = 1/(AI\%/100) \times (EP_{rog}/100)$$

where:

$EF_{pesticide}$	= pesticide-specific emissions factor (lb VOC / lb AI)
AI%	= average mass percent of active ingredient in pesticide
EP_{rog}	= emissions potential of reactive organic gases (expressed as % of pesticide mass)

For active ingredients not in the DPR database, a weighted average emission factor (EF_{avg}) was calculated. This weighted average was estimated by weighting the emission factors from the DPR database using the total pounds of active ingredient reported in the USGS report “Estimated Annual Agricultural Pesticide Use for Counties of the Conterminous United States, 2008-2012” [ref 3]. A crosswalk between compound name in the USGS database and the chemical name in the CA DPR database is provided in Table 4-136.

$$EF_{avg} = \Sigma_{pesticides}(EF_{pesticide} \times AI/T)$$

where:

EF_{avg}	= average emissions factor (lb VOC / lb AI)
$EF_{pesticide}$	= pesticide-specific emissions factor (lb VOC / lb AI)
AI	= active ingredient applied (lb)
T	= total mass of all active ingredients applied (lb)

This resulted in an EF_{avg} value of 0.4 pounds of VOC per pound of active ingredient. The VOC emission factors by active ingredient are shown in Table 4-137.

For the estimation of HAP emissions, a variation of the EIIP’s preferred method (9-4.1) based on vapor pressure of the active ingredient was implemented. The subset of HAPs was extracted from the list of active ingredients and is shown in Table 4-138 along with the HAP emission factors. Note that these HAPs are also VOCs and are therefore included in the pesticide-specific VOC emission factors calculated above.

The HAP emissions are based on the quantity of active ingredient applied and are estimated as follows:

$$E_{HAP} = AI \times EF_{HAP}$$

where:

E_{HAP} = HAP emissions from pesticide active ingredient applications in pounds;

EF_{HAP} = emission factor in pounds of emission per pound of active ingredient from EIIP Table 9.4-4 based on vapor pressure of HAP. If the EIIP method resulted in HAP emissions exceeding VOC emissions, then the emissions factor was set to the pesticide-specific VOC emissions factor calculated above for total VOC emissions.

Table 4-136: Crosswalk between USGS compound name and CA DPR chemical name

USGS compound name	**CA DPR chemical name**
2,4-D	2,4-D
2,4-DB	2,4-DB ACID
6-BENZYLADENINE	AVERAGE
ABAMECTIN	ABAMECTIN
ACEPHATE	ACEPHATE
ACEQUINOCYL	ACEQUINOCYL
ACETAMIPRID	ACETAMIPRID
ACETOCHLOR	AVERAGE
ACIBENZOLAR	ACIBENZOLAR-S-METHYL
ACIFLUORFEN	ACIFLUORFEN, SODIUM SALT
ALACHLOR	ALACHLOR
ALDICARB	ALDICARB
ALUMINUM PHOSPHIDE	ALUMINUM PHOSPHIDE
AMECTOCTRADIN	AMETOCTRADIN
AMETRYN	AMETRYNE
AMINOPYRALID	AMINOPYRALID, TRIISOPROPANOLAMINE SALT
ASULAM	ASULAM, SODIUM SALT
ATRAZINE	ATRAZINE
AVIGLYCINE	AVERAGE
AZADIRACHTIN	AZADIRACHTIN
AZINPHOS-METHYL	AZINPHOS-METHYL
AZOXYSTROBIN	AZOXYSTROBIN
BACILLUS AMYLOLIQUIFACIEN	BACILLUS AMYLOLIQUEFACIENS STRAIN D747
BACILLUS CEREUS	BACILLUS CEREUS, STRAIN BP01
BACILLUS FIRMUS	BACILLUS FIRMUS (STRAIN I-1582)
BACILLUS PUMILIS	BACILLUS PUMILUS GHA 180
BACILLUS SUBTILIS	BACILLUS SUBTILIS GB03
BACILLUS THURINGIENSIS	BACILLUS THURINGIENSIS (BERLINER)
BENFLURALIN	AVERAGE
BENOMYL	BENOMYL
BENSULFURON	BENSULFURON METHYL
BENSULIDE	BENSULIDE
BENTAZONE	BENTAZON, SODIUM SALT
BIFENAZATE	BIFENAZATE
BIFENTHRIN	BIFENTHRIN
BISPYRIBAC	BISPYRIBAC-SODIUM
BOSCALID	BOSCALID

USGS compound name	CA DPR chemical name
BROMACIL	BROMACIL
BROMOXYNIL	BROMOXYNIL BUTYRATE
BUPROFEZIN	BUPROFEZIN
BUTRALIN	AVERAGE
CALCIUM POLYSULFIDE	AVERAGE
CAPTAN	CAPTAN
CARBARYL	CARBARYL
CARBOPHENOTHION	CARBOPHENOTHION
CARBOXIN	CARBOXIN
CARFENTRAZONE-ETHYL	CARFENTRAZONE-ETHYL
CHINOMETHIONAT	AVERAGE
CHLORANTRANILIPROLE	CHLORANTRANILIPROLE
CHLORETHOXYFOS	AVERAGE
CHLORFENAPYR	CHLORFENAPYR
CHLORIMURON	AVERAGE
CHLORMEQUAT	CHLORMEQUAT CHLORIDE
CHLORONEB	CHLORONEB
CHLOROPICRIN	CHLOROPICRIN
CHLOROPICRIN	CHLOROPICRIN
CHLOROPICRIN	CHLOROPICRIN
CHLOROPICRIN	CHLOROPICRIN
CHLOROPICRIN	CHLOROPICRIN
CHLOROTHALONIL	CHLOROTHALONIL
CHLORPROPHAM	CHLORPROPHAM
CHLORPYRIFOS	CHLORPYRIFOS
CHLORSULFURON	CHLORSULFURON
CLETHODIM	CLETHODIM
CLODINAFOP	AVERAGE
CLOFENTEZINE	CLOFENTEZINE
CLOMAZONE	CLOMAZONE
CLOPYRALID	CLOPYRALID
CLORANSULAM-METHYL	AVERAGE
CLOTHIANIDIN	CLOTHIANIDIN
CONIOTHYRIUM MINITANS	CONIOTHYRIUM MINITANS STRAIN CON/M/91-08
COPPER	COPPER
COPPER HYDROXIDE	COPPER HYDROXIDE
COPPER OCTANOATE	COPPER OCTANOATE
COPPER OXYCHLORIDE	COPPER OXYCHLORIDE
COPPER OXYCHLORIDE S	COPPER OXYCHLORIDE SULFATE
COPPER SULF TRIBASIC	COPPER SULFATE (BASIC)
COPPER SULFATE	COPPER SULFATE (PENTAHYDRATE)
CPPU	AVERAGE

USGS compound name	CA DPR chemical name
CRYOLITE	CRYOLITE
CUPROUS OXIDE	COPPER OXIDE (OUS)
CYANAMIDE	AVERAGE
CYAZOFAMID	CYAZOFAMID
CYCLANILIDE	CYCLANILIDE
CYCLOATE	CYCLOATE
CYDIA POMONELLA	AVERAGE
CYFLUFENAMID	CYFLUFENAMID
CYFLUTHRIN	CYFLUTHRIN
CYHALOFOP	CYHALOFOP-BUTYL
CYHALOTHRIN-GAMMA	AVERAGE
CYHALOTHRIN-LAMBDA	AVERAGE
CYMOXANIL	CYMOXANIL
CYPERMETHRIN	CYPERMETHRIN
CYPROCONAZOLE	AVERAGE
CYPRODINIL	CYPRODINIL
CYROMAZINE	CYROMAZINE
CYTOKININ	CYTOKININ
DAMINOZIDE	DAMINOZIDE
DAZOMET	DAZOMET
DCPA	AVERAGE
DECAN-1-OL	AVERAGE
DELTAMETHRIN	DELTAMETHRIN
DESMEDIPHAM	DESMEDIPHAM
DIAZINON	DIAZINON
DICAMBA	DICAMBA
DICHLOBENIL	DICHLOBENIL
DICHLOROPROPENE	AVERAGE
DICHLORPROP	DICHLORPROP, BUTOXYETHANOL ESTER
DICLOFOP	DICLOFOP-METHYL
DICLORAN	DICLORAN
DICLOSULAM	AVERAGE
DICOFOL	DICOFOL
DICROTOPHOS	DICROTOPHOS
DIENOCHLOR	DIENOCHLOR
DIETHATYL	DIETHATYL-ETHYL
DIFENOCONAZOLE	DIFENOCONAZOLE
DIFLUBENZURON	DIFLUBENZURON
DIFLUFENZOPYR	DIFLUBENZURON
DIMETHENAMID	DIMETHENAMID-P
DIMETHENAMID-P	DIMETHENAMID-P
DIMETHIPIN	DIMETHIPIN

USGS compound name	CA DPR chemical name
DIMETHOATE	DIMETHOATE
DIMETHOMORPH	DIMETHOMORPH
DIMETHYL DISULFIDE	AVERAGE
DINOSEB	DINOSEB
DINOTEFURAN	DINOTEFURAN
DIQUAT	DIQUAT DIBROMIDE
DISULFOTON	DISULFOTON
DITHIOPYR	DITHIOPYR
DIURON	DIURON
DODINE	DODINE
EMAMECTIN	EMAMECTIN BENZOATE
ENDOSULFAN	ENDOSULFAN
ENDOTHAL	ENDOTHALL, DISODIUM SALT
EPTC	EPTC
ESFENVALERATE	ESFENVALERATE
ETHALFLURALIN	ETHALFLURALIN
ETHEPHON	ETHEPHON
ETHION	ETHION
ETHOFUMESATE	ETHOFUMESATE
ETHOPROPHOS	ETHOPROP
ETOXAZOLE	ETOXAZOLE
ETRIDIAZOLE	AVERAGE
FAMOXADONE	AVERAGE
FATTY ALCOHOLS	AVERAGE
FENAMIDONE	FENAMIDONE
FENAMIPHOS	FENAMIPHOS
FENARIMOL	FENARIMOL
FENBUCONAZOLE	FENBUCONAZOLE
FENBUTATIN OXIDE	FENBUTATIN-OXIDE
FENHEXAMID	FENHEXAMID
FENOXAPROP	FENOXAPROP-ETHYL
FENOXYCARB	FENOXYCARB
FENPROPATHRIN	FENPROPATHRIN
FENPYROXIMATE	FENPYROXIMATE
FENTIN	FENTIN HYDROXIDE
FERBAM	FERBAM
FIPRONIL	FIPRONIL
FLAZASULFURON	FLAZASULFURON
FLONICAMID	FLONICAMID
FLORASULAM	FLORASULAM
FLUAZIFOP	FLUAZIFOP-BUTYL
FLUAZINAM	FLUAZINAM

USGS compound name	CA DPR chemical name
FLUBENDIAMIDE	FLUBENDIAMIDE
FLUCARBAZONE	AVERAGE
FLUDIOXONIL	FLUDIOXONIL
FLUFENACET	AVERAGE
FLUMETRALIN	FLUOMETURON
FLUMETSULAM	AVERAGE
FLUMICLORAC	FLUMICLORAC-PENTYL
FLUMIOXAZIN	FLUMIOXAZIN
FLUOMETURON	FLUOMETURON
FLUOPICOLIDE	FLUOPICOLIDE
FLUOPYRAM	FLUOPYRAM
FLUOXASTROBIN	FLUOXASTROBIN
FLURIDONE	FLURIDONE
FLUROXYPYR	FLUROXYPYR
FLUTHIACET-METHYL	AVERAGE
FLUTOLANIL	FLUTOLANIL
FLUTRIAFOL	FLUTRIAFOL
FLUVALINATE-TAU	AVERAGE
FLUXAPYROXAD	FLUXAPYROXAD
FOMESAFEN	AVERAGE
FORAMSULFURON	FORAMSULFURON
FORMETANATE	FORMETANATE HYDROCHLORIDE
FOSETYL	FOSETYL-AL
GALLEX	META-CRESOL
GAMMA AMINOBUTYRIC ACID	AVERAGE
GIBBERELLIC ACID	GIBBERELLINS
GLUFOSINATE	GLUFOSINATE-AMMONIUM
GLYPHOSATE	GLYPHOSATE
HALOSULFURON	HALOSULFURON-METHYL
HARPIN PROTEIN	HARPIN PROTEIN
HEXAZINONE	HEXAZINONE
HEXYTHIAZOX	HEXYTHIAZOX
HYDRAMETHYLNON	HYDRAMETHYLNON
HYDRATED LIME	CALCIUM HYDROXIDE
HYDROGEN PEROXIDE	HYDROGEN PEROXIDE
HYMEXAZOL	AVERAGE
IBA	IBA
IMAZALIL	IMAZALIL
IMAZAMETHABENZ	IMAZAMETHABENZ
IMAZAMOX	IMAZAMOX
IMAZAPIC	IMAZAPIC
IMAZAPYR	IMAZAPYR

USGS compound name	CA DPR chemical name
IMAZAQUIN	AVERAGE
IMAZETHAPYR	IMAZETHAPYR
IMAZOSULFURON	IMAZOSULFURON
IMIDACLOPRID	IMIDACLOPRID
INDAZIFLAM	INDAZIFLAM
INDOXACARB	INDOXACARB
IODOSULFURON	AVERAGE
IPCONAZOLE	IPCONAZOLE
IPRODIONE	IPRODIONE
ISOXABEN	ISOXABEN
ISOXAFLUTOLE	AVERAGE
KAOLIN CLAY	KAOLIN
KINOPRENE	KINOPRENE
KRESOXIM-METHYL	KRESOXIM-METHYL
LACTOFEN	AVERAGE
L-GLUTAMIC ACID	GLUTAMIC ACID
LINURON	LINURON
MALATHION	MALATHION
MALEIC HYDRAZIDE	MALEIC HYDRAZIDE
MANCOZEB	MANCOZEB
MANDIPROPAMID	MANDIPROPAMID
MANEB	MANEB
MCPA	MCPA
MCPB	MCPB, SODIUM SALT
MECOPROP	MECOPROP-P
MEFENOXAM	MEFENOXAM
MEPIQUAT	MEPIQUAT CHLORIDE
MESOSULFURON	MESOSULFURON-METHYL
MESOTRIONE	MESOTRIONE
METALAXYL	METALAXYL
METALDEHYDE	METALDEHYDE
METAM	METAM-SODIUM
METAM POTASSIUM	METAM-SODIUM
METCONAZOLE	METCONAZOLE
METHAMIDOPHOS	METHAMIDOPHOS
METHIDATHION	METHIDATHION
METHIOCARB	METHIOCARB
METHOMYL	METHOMYL
METHOXYFENOZIDE	METHOXYFENOZIDE
METHYL BROMIDE	METHYL BROMIDE
METHYL BROMIDE	METHYL BROMIDE
METHYL IODIDE	METHYL IODIDE

USGS compound name	CA DPR chemical name
METHYL PARATHION	METHYL PARATHION
METIRAM	METIRAM
METOLACHLOR	METOLACHLOR
METOLACHLOR-S	METOLACHLOR
METRAFENONE	METRAFENONE
METRIBUZIN	METRIBUZIN
METSULFURON	METSULFURON-METHYL
MEVINPHOS	MEVINPHOS
MSMA	MSMA
MYCLOBUTANIL	MYCLOBUTANIL
MYROTHECIUM VERRUCARIA	MYROTHECIUM VERRUCARIA, DRIED FERMENTATION SOLIDS
NALED	NALED
NAPHTHYLACETAMIDE	AVERAGE
NAPHTHYLACETIC ACID	AVERAGE
NAPROPAMIDE	NAPROPAMIDE
NAPTALAM	NAPTALAM, SODIUM SALT
NEEM OIL	AVERAGE
NICOSULFURON	NICOSULFURON
NORFLURAZON	NORFLURAZON
NOSEMA LOCUSTAE CANN	NOSEMA LOCUSTAE SPORES
NOVALURON	NOVALURON
ORTHOSULFAMURON	ORTHOSULFAMURON
ORYZALIN	ORYZALIN
OXADIAZON	OXADIAZON
OXAMYL	OXAMYL
OXYDEMETON-METHYL	OXYDEMETON-METHYL
OXYFLUORFEN	OXYFLUORFEN
OXYTETRACYCLINE	OXYTETRACYCLINE HYDROCHLORIDE
PACLOBUTRAZOL	PACLOBUTRAZOL
PARAQUAT	PARAQUAT DICHLORIDE
PARATHION	PARATHION
PELARGONIC ACID	AVERAGE
PENDIMETHALIN	PENDIMETHALIN
PENOXSULAM	PENOXSULAM
PENTHIOPYRAD	PENTHIOPYRAD
PERMETHRIN	PERMETHRIN
PETROLEUM DISTILLATE	PETROLEUM DISTILLATES
PETROLEUM OIL	PETROLEUM NAPHTHENIC OILS
PHENMEDIPHAM	PHENMEDIPHAM
PHORATE	PHORATE
PHOSMET	PHOSMET
PHOSPHORIC ACID	PHOSPHORIC ACID

USGS compound name	**CA DPR chemical name**
PICLORAM	PICLORAM
PINOXADEN	PINOXADEN
PIPERONYL BUTOXIDE	PIPERONYL BUTOXIDE
POLYHEDROSIS VIRUS	POLYHEDRAL OCCLUSION BODIES (OB'S) OF THE NUCLEAR
POLYOXORIM	AVERAGE
POTASSIUM BICARBONATE	POTASSIUM BICARBONATE
POTASSIUM OLEATE	AVERAGE
PRIMISULFURON	AVERAGE
PRODIAMINE	PRODIAMINE
PROFENOFOS	PROFENOFOS
PROHEXADIONE	PROHEXADIONE CALCIUM
PROMETRYN	PROMETRYN
PROPAMOCARB HCL	PROPAMOCARB HYDROCHLORIDE
PROPANIL	PROPANIL
PROPARGITE	PROPARGITE
PROPAZINE	PROPAZINE
PROPICONAZOLE	PROPICONAZOLE
PROPOXYCARBAZONE	AVERAGE
PROPYZAMIDE	PROPYZAMIDE
PROSULFURON	AVERAGE
PROTHIOCONAZOLE	PROTHIOCONAZOLE
PSEUDOMONAS FLUORESCENS	PSEUDOMONAS FLUORESCENS, STRAIN A506
PYMETROZINE	PYMETROZINE
PYRACLOSTROBIN	PYRACLOSTROBIN
PYRAFLUFEN ETHYL	PYRAFLUFEN-ETHYL
PYRASULFOTOLE	AVERAGE
PYRETHRINS	PYRETHRINS
PYRIDABEN	PYRIDABEN
PYRIMETHANIL	PYRIMETHANIL
PYRIPROXYFEN	PYRIPROXYFEN
PYRITHIOBAC-SODIUM	PYRITHIOBAC-SODIUM
PYROXASULFONE	AVERAGE
PYROXSULAM	PYROXSULAM
QUINCLORAC	QUINCLORAC
QUINOXYFEN	QUINOXYFEN
QUINTOZENE	AVERAGE
QUIZALOFOP	QUIZALOFOP-ETHYL
RIMSULFURON	RIMSULFURON
ROTENONE	ROTENONE
SABADILLA	SABADILLA ALKALOIDS
SAFLUFENACIL	SAFLUFENACIL

USGS compound name	CA DPR chemical name
SETHOXYDIM	SETHOXYDIM
SILICATES	SILICA AEROGEL
SIMAZINE	SIMAZINE
SODIUM CHLORATE	SODIUM CHLORATE
SODIUM CHLORATE	SODIUM CHLORATE
SPINETORAM	SPINETORAM
SPINOSYN	SPINOSAD
SPIRODICLOFEN	SPIRODICLOFEN
SPIROMESIFEN	SPIROMESIFEN
SPIROTETRAMAT	SPIROTETRAMAT
STREPTOMYCIN	STREPTOMYCIN
SULFCARBAMIDE	AVERAGE
SULFENTRAZONE	SULFENTRAZONE
SULFOMETURON	SULFOMETURON-METHYL
SULFOSATE	AVERAGE
SULFOSULFURON	SULFOSULFURON
SULFOXAFLOR	SULFOXAFLOR
SULFUR	SULFUR
SULFURIC ACID	SULFURIC ACID
TCMTB	TCMTB
TEBUCONAZOLE	TEBUCONAZOLE
TEBUFENOZIDE	TEBUFENOZIDE
TEBUPIRIMPHOS	AVERAGE
TEBUTHIURON	TEBUTHIURON
TEFLUTHRIN	AVERAGE
TEMBOTRIONE	TEMBOTRIONE
TERBACIL	TERBACIL
TERBUFOS	AVERAGE
TETRABOROHYDRATE	AVERAGE
TETRACONAZOLE	TETRACONAZOLE
TETRATHIOCARBONATE	AVERAGE
THIABENDAZOLE	THIABENDAZOLE
THIACLOPRID	THIACLOPRID
THIAMETHOXAM	THIAMETHOXAM
THIAZOPYR	THIAZOPYR
THIDIAZURON	THIDIAZURON
THIENCARBAZONE-METHYL	AVERAGE
THIFENSULFURON	THIFENSULFURON-METHYL
THIOBENCARB	THIOBENCARB
THIODICARB	THIODICARB
THIOPHANATE-METHYL	THIOPHANATE-METHYL
THIRAM	THIRAM

USGS compound name	CA DPR chemical name
TOPRAMEZONE	AVERAGE
TRALKOXYDIM	TRALKOXYDIM
TRIADIMEFON	TRIADIMEFON
TRIADIMENOL	TRIADIMENOL
TRI-ALLATE	TRIALLATE
TRIASULFURON	AVERAGE
TRIBENURON METHYL	TRIBENURON-METHYL
TRIBUFOS	AVERAGE
TRICLOPYR	TRICLOPYR, BUTOXYETHYL ESTER
TRIFLOXYSTROBIN	TRIFLOXYSTROBIN
TRIFLOXYSULFURON	TRIFLOXYSULFURON-SODIUM
TRIFLUMIZOLE	TRIFLUMIZOLE
TRIFLURALIN	TRIFLURALIN
TRIFLUSULFURON	AVERAGE
TRINEXAPAC	TRINEXAPAC-ETHYL
TRITICONAZOLE	TRITICONAZOLE
UNICONAZOLE	UNICONIZOLE-P
VINCLOZOLIN	VINCLOZOLIN
ZETA-CYPERMETHRIN	AVERAGE
ZINC	ZINC CHLORIDE
ZINEB	ZINEB
ZIRAM	ZIRAM
ZOXAMIDE	AVERAGE

Table 4-137: VOC emission factors for EPA-estimated Agricultural Pesticide Application

PESTICIDE	Average VOC per LB AI (lb)
2,4-D	0.827
2,4-DB ACID	0.067
ABAMECTIN	15.236
ACEPHATE	0.275
ACEQUINOCYL	0.135
ACETAMIPRID	0.207
ACIBENZOLAR-S-METHYL	0.063
ACIFLUORFEN, SODIUM SALT	1.887
ALACHLOR	0.513
ALDICARB	0.064
ALUMINUM PHOSPHIDE	0.055
AMETOCTRADIN	0.041
AMETRYNE	0.024
AMINOPYRALID, TRIISOPROPANOLAMINE SALT	0.16
ASULAM, SODIUM SALT	0.202
ATRAZINE	0.148

PESTICIDE	Average VOC per LB AI (lb)
AZADIRACHTIN	10.092
AZINPHOS-METHYL	0.464
AZOXYSTROBIN	0.344
BACILLUS AMYLOLIQUEFACIENS STRAIN D747	0.076
BACILLUS CEREUS, STRAIN BP01	0.106
BACILLUS FIRMUS (STRAIN I-1582)	0.052
BACILLUS PUMILUS GHA 180	2,050.00
BACILLUS SUBTILIS GB03	190.333
BACILLUS THURINGIENSIS (BERLINER)	0.487
BENOMYL	0.074
BENSULFURON METHYL	0.031
BENSULIDE	0.553
BENTAZON, SODIUM SALT	0.053
BIFENAZATE	0.084
BIFENTHRIN	1.566
BISPYRIBAC-SODIUM	0.038
BOSCALID	0.229
BROMACIL	0.85
BUPROFEZIN	0.164
CALCIUM HYDROXIDE	0.003
CAPTAN	0.144
CARBARYL	0.321
CARBOPHENOTHION	0.446
CARBOXIN	0.437
CARFENTRAZONE-ETHYL	0.653
CHLORANTRANILIPROLE	0.364
CHLORFENAPYR	0.137
CHLORMEQUAT CHLORIDE	0.586
CHLORONEB	0.074
CHLOROPICRIN	1.272
CHLOROTHALONIL	0.113
CHLORPROPHAM	0.325
CHLORPYRIFOS	1.538
CHLORSULFURON	0.028
CLETHODIM	1.84
CLOFENTEZINE	0.147
CLOMAZONE	0.149
CLOPYRALID	0.05
CLOTHIANIDIN	0.153
CONIOTHYRIUM MINITANS STRAIN CON/M/91-08	0.698
COPPER	0.218
COPPER HYDROXIDE	0.06

PESTICIDE	Average VOC per LB AI (lb)
COPPER OCTANOATE	2.198
COPPER OXIDE (OUS)	0.029
COPPER OXYCHLORIDE	0.023
COPPER OXYCHLORIDE SULFATE	0.026
COPPER SULFATE (BASIC)	0.048
COPPER SULFATE (PENTAHYDRATE)	0.062
CRYOLITE	0.025
CYAZOFAMID	0.166
CYCLANILIDE	2.468
CYCLOATE	0.507
CYFLUFENAMID	0.175
CYFLUTHRIN	1.736
CYHALOFOP-BUTYL	0.452
CYMOXANIL	0.044
CYPERMETHRIN	1.521
CYPRODINIL	0.049
CYROMAZINE	0.228
CYTOKININ	0.254
DAMINOZIDE	0.045
DAZOMET	1
DELTAMETHRIN	3.949
DESMEDIPHAM	3.668
DIAZINON	0.76
DICAMBA	0.084
DICHLOBENIL	0.434
DICLOFOP-METHYL	1.042
DICLORAN	0.087
DICOFOL	0.424
DICROTOPHOS	0.258
DIENOCHLOR	0.182
DIFENOCONAZOLE	1.12
DIFLUBENZURON	0.159
DIMETHENAMID-P	0.135
DIMETHIPIN	0.367
DIMETHOATE	0.83
DIMETHOMORPH	0.038
DINOSEB	0.455
DINOTEFURAN	0.191
DIQUAT DIBROMIDE	1.456
DISULFOTON	1.186
DITHIOPYR	0.955
DIURON	0.072

PESTICIDE	Average VOC per LB AI (lb)
DODINE	0.049
EMAMECTIN BENZOATE	3.055
ENDOSULFAN	0.492
EPTC	0.517
ESFENVALERATE	8.919
ETHALFLURALIN	1.554
ETHEPHON	0.302
ETHION	0.397
ETHOFUMESATE	0.691
ETHOPROP	0.416
ETOXAZOLE	0.059
FENAMIDONE	0.101
FENAMIPHOS	1.043
FENARIMOL	1.404
FENBUCONAZOLE	0.049
FENBUTATIN-OXIDE	0.058
FENHEXAMID	0.037
FENOXAPROP-ETHYL	3.132
FENOXYCARB	0.655
FENPROPATHRIN	1.469
FENPYROXIMATE	8.721
FENTIN HYDROXIDE	0.039
FERBAM	0.045
FIPRONIL	6.463
FLAZASULFURON	0.148
FLONICAMID	0.06
FLORASULAM	0.052
FLUAZIFOP-BUTYL	1.464
FLUAZINAM	0.406
FLUBENDIAMIDE	0.102
FLUDIOXONIL	0.308
FLUMICLORAC-PENTYL	0.565
FLUMIOXAZIN	0.075
FLUOMETURON	0.046
FLUOPICOLIDE	0.136
FLUOPYRAM	0.291
FLUOXASTROBIN	0.172
FLURIDONE	0.629
FLUROXYPYR	0.279
FLUTOLANIL	0.031
FLUTRIAFOL	0.331
FLUXAPYROXAD	0.02

PESTICIDE	**Average VOC per LB AI (lb)**
FORAMSULFURON	0.252
FORMETANATE HYDROCHLORIDE	0.011
FOSETYL-AL	0.049
GIBBERELLINS	2.819
GLUFOSINATE-AMMONIUM	0.442
GLUTAMIC ACID	0.063
GLYPHOSATE	0.159
HALOSULFURON-METHYL	0.032
HARPIN PROTEIN	1.233
HEXAZINONE	0.142
HEXYTHIAZOX	0.423
HYDRAMETHYLNON	0.614
HYDROGEN PEROXIDE	0.356
IBA	0.559
IMAZALIL	0.794
IMAZAMETHABENZ	0.504
IMAZAMOX	0.016
IMAZAPIC	0.016
IMAZAPYR	0.025
IMAZETHAPYR	0.019
IMAZOSULFURON	0.049
IMIDACLOPRID	0.305
INDAZIFLAM	0.416
INDOXACARB	0.453
IPCONAZOLE	0.122
IPRODIONE	0.203
ISOXABEN	0.103
KAOLIN	0.015
KINOPRENE	0.466
KRESOXIM-METHYL	0.034
LINURON	0.077
MALATHION	0.409
MALEIC HYDRAZIDE	0.015
MANCOZEB	0.047
MANDIPROPAMID	0.209
MANEB	0.071
MCPA	0.47
MCPB, SODIUM SALT	1.206
MECOPROP-P	0.622
MEFENOXAM	0.587
MEPIQUAT CHLORIDE	0.661
MESOSULFURON-METHYL	0.822

PESTICIDE	Average VOC per LB AI (lb)
MESOTRIONE	0.236
META-CRESOL	73.605
METALAXYL	0.506
METALDEHYDE	0.691
METAM-SODIUM	0.566
METCONAZOLE	0.369
METHAMIDOPHOS	0.71
METHIDATHION	1.068
METHIOCARB	0.22
METHOMYL	0.115
METHOXYFENOZIDE	0.223
METHYL BROMIDE	1.159
METHYL IODIDE	1.212
METHYL PARATHION	0.502
METIRAM	0.11
METOLACHLOR	0.198
METRAFENONE	0.074
METRIBUZIN	0.087
METSULFURON-METHYL	0.037
MEVINPHOS	0.534
MSMA	0.315
MYCLOBUTANIL	0.451
MYROTHECIUM VERRUCARIA, DRIED FERMENTATION SOLIDS	0.127
NALED	0.494
NAPROPAMIDE	0.385
NAPTALAM, SODIUM SALT	0.588
NICOSULFURON	0.037
NORFLURAZON	0.031
NOSEMA LOCUSTAE SPORES	7.085
NOVALURON	2.273
ORTHOSULFAMURON	0.097
ORYZALIN	0.212
OXADIAZON	0.182
OXAMYL	0.721
OXYDEMETON-METHYL	0.928
OXYFLUORFEN	1.012
OXYTETRACYCLINE HYDROCHLORIDE	0.199
PACLOBUTRAZOL	0.983
PARAQUAT DICHLORIDE	0.311
PARATHION	0.357
PENDIMETHALIN	0.559
PENOXSULAM	0.208

PESTICIDE	Average VOC per LB AI (lb)
PENTHIOPYRAD	0.054
PERMETHRIN	3.345
PETROLEUM DISTILLATES	1.142
PETROLEUM NAPHTHENIC OILS	0.884
PHENMEDIPHAM	3.129
PHORATE	0.448
PHOSMET	1.162
PHOSPHORIC ACID	0.434
PICLORAM	0.398
PINOXADEN	10.388
PIPERONYL BUTOXIDE	4.504
POLYHEDRAL OCCLUSION BODIES (OB'S) OF THE NUCLEAR	8.922
POTASSIUM BICARBONATE	0.027
PRODIAMINE	0.126
PROFENOFOS	0.367
PROMETRYN	0.184
PROPAMOCARB HYDROCHLORIDE	0.18
PROPANIL	0.099
PROPARGITE	0.196
PROPAZINE	0.2
PROPICONAZOLE	1.052
PROPYZAMIDE	0.055
PROTHIOCONAZOLE	0.139
PSEUDOMONAS FLUORESCENS, STRAIN A506	0.022
PYMETROZINE	0.02
PYRACLOSTROBIN	0.549
PYRAFLUFEN-ETHYL	5.343
PYRETHRINS	6.737
PYRIDABEN	0.019
PYRIMETHANIL	0.188
PYRIPROXYFEN	1.387
PYRITHIOBAC-SODIUM	0.193
PYROXSULAM	0.135
QUINCLORAC	0.121
QUINOXYFEN	0.06
QUIZALOFOP-ETHYL	4.121
RIMSULFURON	0.07
ROTENONE	0.808
SABADILLA ALKALOIDS	2.018
SAFLUFENACIL	0.015
SETHOXYDIM	3.751
SILICA AEROGEL	0.381

PESTICIDE	Average VOC per LB AI (lb)
SIMAZINE	0.089
SODIUM CHLORATE	0.025
SPINETORAM	0.138
SPINOSAD	0.483
SPIRODICLOFEN	0.229
SPIROMESIFEN	0.119
SPIROTETRAMAT	0.101
STREPTOMYCIN	0.133
SULFENTRAZONE	0.128
SULFOMETURON-METHYL	0.076
SULFOSULFURON	0.027
SULFOXAFLOR	0.06
SULFUR	0.013
SULFURIC ACID	0.088
TCMTB	0.995
TEBUCONAZOLE	0.178
TEBUFENOZIDE	0.163
TEBUTHIURON	0.075
TEMBOTRIONE	0.096
TERBACIL	0.023
TETRACONAZOLE	0.492
THIABENDAZOLE	0.117
THIACLOPRID	0.119
THIAMETHOXAM	0.178
THIAZOPYR	1.756
THIDIAZURON	0.396
THIFENSULFURON-METHYL	0.049
THIOBENCARB	0.158
THIODICARB	0.133
THIOPHANATE-METHYL	0.118
THIRAM	0.219
TRALKOXYDIM	0.141
TRIADIMEFON	0.162
TRIADIMENOL	0.243
TRIALLATE	0.573
TRIBENURON-METHYL	0.03
TRICLOPYR, BUTOXYETHYL ESTER	0.433
TRIFLOXYSTROBIN	0.083
TRIFLOXYSULFURON-SODIUM	0.014
TRIFLUMIZOLE	0.067
TRIFLURALIN	0.737
TRINEXAPAC-ETHYL	2.386

PESTICIDE	Average VOC per LB AI (lb)
TRITICONAZOLE	0.24
UNICONIZOLE-P	125.636
VINCLOZOLIN	0.055
ZINC CHLORIDE	0.329
ZINEB	0.082
ZIRAM	0.031

Table 4-138: HAP emission factors for EPA-estimated Agricultural Pesticide Application

Compound	Pollutant Code	Vapor Pressure (mm Hg at 20°C to 25°C)	Emission Factor (lb per lb AI)	Source
2,4-D	94757	0.000008	0.35	EIIP, Volume 3, Chapter 9, Table 9.4-4 [ref 1]
CAPTAN	133062	0.00000008	0.1441	Set equal to VOC emissions factor calculated from the CA DPR [ref 2]
CARBARYL	63252	0.0000012	0.3208	Set equal to VOC emissions factor calculated from the CA DPR [ref 2]
METHYL BROMIDE	74839	1,420	0.58	EIIP, Volume 3, Chapter 9, Table 9.4-4 [ref 1]
METHYL IODIDE	74884	400	0.58	EIIP, Volume 3, Chapter 9, Table 9.4-4 [ref 1]
PARATHION	56382	0.0000378	0.35	EIIP, Volume 3, Chapter 9, Table 9.4-4 [ref 1]
TRIFLURALIN	1582098	0.00011	0.58	EIIP, Volume 3, Chapter 9, Table 9.4-4 [ref 1]

4.21.3.2 *Activity data: updated for 2014v2 NEI*

The activity for pesticide application is the pounds of active ingredient applied per pesticide for the year 2013 (versus year 2012 in the 2014v1 NEI). These data are available from the USGS report “Preliminary Estimates of Annual Agricultural Pesticide Use for Counties of the Conterminous United States, 2013” [ref 3], which gives county-level pesticide data in terms of kg of active ingredient applied. The report estimates preliminary annual county-level pesticide use for 387 (vs 423 herbicides in the 2012 report used in 2014v1), insecticides, and fungicides applied to agricultural crops grown in the conterminous United States during 2013. For all States except California, pesticide-use data are compiled from proprietary surveys of farm operations located within U.S. Department of Agriculture Crop Reporting Districts (CRDs). Surveyed pesticide-use data were used in conjunction with county annual harvested-crop acres reported by the U.S. Department of Agriculture 2007 and 2012 Census of Agriculture and the 2013 County Agricultural Production Survey to calculate use rates per harvested-crop acre, or an “estimated pesticide use” (EPest) rate, for each crop by year. County-use estimates were then calculated by multiplying EPest rates by harvested-crop acres for each pesticide crop combination. Use estimates for California were obtained from annual Department of Pesticide Regulation-Pesticide Use Reports.

The USGS report calculates both EPest-low and EPest-high rates. The EPest-high rates were used here to estimate VOC emissions. Both methods incorporated surveyed and extrapolated rates to estimate pesticide use for counties, but EPest-low and EPest-high estimations differed in how they treated situations when a CRD was surveyed and pesticide use was not reported for a particular pesticide-by-crop combination. If use of a pesticide on a crop was not reported in a surveyed CRD, EPest-low reports zero use in the CRD for that pesticide-by-crop combination. EPest-high, however, treats the unreported use for that pesticide-by-crop combination in the CRD as un-surveyed, and pesticide-by-crop use rates from neighboring CRDs and, in some cases, CRDs within the same Farm Resources Region are used to calculate the pesticide-by-crop EPest-high rate for the CRD.

Due to data limitations in the USGS report, active ingredient usages for Alaska and Hawaii were pulled forward from 2011.

4.21.3.3 *Controls*

No controls were accounted for in the emissions estimation.

4.21.3.4 *Example Calculation*

Emissions were estimated by summing the product of the active ingredient applied and the emissions factor for each pesticide at the county-level:

$$\text{Total VOC Emissions}_{county} = \Sigma_{pesticide}\ (\text{AI} \times \text{EF})$$

Taking Autauga County, Alabama as an example:

> 2,874.9 kg of active ingredient of 2,4-D was applied
> 2,874.9 kg × 2.20462 lb/kg = 6,338.1 lb active ingredient.
> $EF_{2,4\text{-}D}$ = 0.8273 (lb VOC/lb AI)

Emissions are calculated by multiplying activity data by the emissions factor:

> $\text{Emissions}_{Autauga,2,4\text{-}D}$ = 6,338.1 lb AI × 0.8273 lb VOC/lb AI = 5,244 lb VOC

This process was then repeated for all pesticide compounds and summed to the county level, resulting in approximately 39,585 lb, or 19.8 tons, of VOC emitted due to agricultural pesticide application in Autauga County.

4.21.3.5 *Changes from 2011 and 2014v1 Methodology*

In the 2011 inventory, data estimating harvested acres per crop in each county was multiplied by the percent of acres treated to yield the number of acres treated for each combination of crop and pesticide compound in a given county. This acreage was multiplied by an application rate of active ingredient applied per treated acre (calculated using Crop Life Foundation Database application rates and 2007 USDA Census of Agriculture harvest acres). The result was the pounds of active ingredient applied for each compound and crop type at the county level. The mass of active ingredient was then multiplied by an average emissions factor derived from the CA DPR pesticide database.

Since the Crop Life Foundation Database was discontinued in 2008, the 2014 inventory uses county-level active ingredient applied for all crop types from the USGS report for year 2012 in the 2014v1 NEI and for year 2013 in the 2014v2 NEI. The amount of active ingredient (kg) applied was available at the county level by pesticide compound, but not by crop. The mass of active ingredient was then multiplied by pesticide-specific emission factors derived from the CA DPR 2015 pesticide database (rather than an average emissions factor). In addition, the 2014 methodology includes HAP emissions estimates for all counties, except those in Alaska, Hawaii, Puerto Rico and the U.S. Virgin Islands (due to data limitations).

4.21.3.6 *Puerto Rico and US Virgin Islands Emissions Calculations*

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and

Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

4.21.4 References for agricultural pesticides

1. United States Environmental Protection Agency, "*Pesticides - Agricultural and Nonagricultural*", Vol. 3, Ch. 9, Section 5.1, p. 9.5-4, Emissions Inventory Improvement Program, June 2001.
2. California Department of Pesticide Regulation, "CDPR_Emission_Potential_Database_10_2015.xlsx", provided by Pam Wofford, Environmental Program Manager, CA DPR to Jonathan Dorn, Associate, Abt Associates (January 2016).
3. United States Geological Survey, Preliminary Estimates of Annual Agricultural Pesticide Use for Counties of the Conterminous United States, 2013, accessed July 2016.

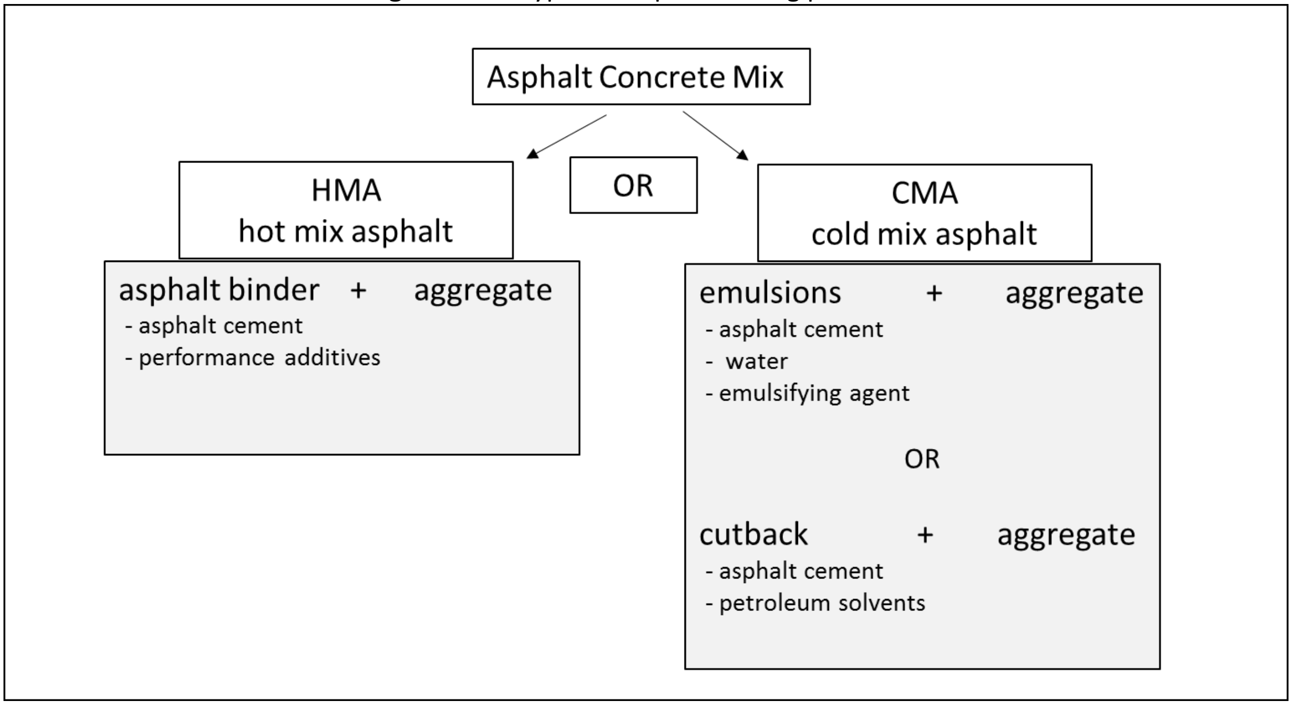
4.22 Solvent – Consumer & Commercial Use: Asphalt Paving - Cutback and Emulsified

4.22.1 Sector description

Asphalts for paving are mainly used in two ways. They are either mixed with aggregates at plants and hauled to the paving site and then compacted on the road, or they are sprayed in relatively thin layers with or without aggregates. Plant mixed asphalt products are called asphalt concrete mix. As seen in Figure 4-20, these can be produced and laid down hot, using asphalt cements, or cold, using emulsions or cutbacks. These mixes usually contain about 5% asphalt and 95% aggregates by weight. Aggregates give the mix most of its ability to carry or resist loads while the asphalt coats and binds the aggregate structure.

Hot laid mixes, also called hot mix asphalt (HMA), are produced by mixing heated aggregates and asphalt cements in special mixing plants. These very strong, stiff mixes are usually used for surface and subsurface layers in highways, airports, parking lots, and other areas which carry heavy or high-volume traffic. HMA uses an asphaltic binding agent which includes asphalt cement as well as any material added to modify the original asphalt cement properties. Cold asphalt mixes are produced by mixing damp, cold aggregates with emulsions or cutbacks at mixing plants — either stationary plants or portable ones brought to the site. Although not as strong and stiff as hot mix, cold mixes may be more economical and flexible, and less polluting. They are used for areas with intermediate and low traffic, for open graded mixes, and for patching. Sprayed asphalt applications include asphalt-aggregate applications, usually called surface treatments or seal coats, and asphalt-only applications such as tack coat, prime coat, fog seal, and dust prevention [ref 1].

Figure 4-20: Types of Asphalt Paving processes



A new, third type of mix, warm-mix asphalt (WMA), has become increasingly popular. In this type of mixture, various methods are used to significantly reduce mix production temperature by 30 to over 100°F. These methods include (1) using chemical additives to lower the high-temperature viscosity of the asphalt binder; (2) techniques involving the addition of water to the binder, causing it to foam; and (3) two-stage processes involving the addition of hard and soft binders at different points during mix production. WMA has several benefits, including lower cost (since significantly less fuel is needed to heat the mix), lower emissions and so improved environmental impact, and potentially improved performance because of decreased age hardening [ref 2].

4.22.2 Sources of data

As seen in Table 4-139, this source category includes data from the S/L/T agency submitted data and the default EPA generated emissions. EPA estimates emissions for both cutback and emulsified asphalt paving. New Jersey and Maryland also reported emissions for "Asphalt Application: All Processes; Total: All Solvent Types" (2461020000). The leading SCC description is "Solvent Utilization; Miscellaneous Non-industrial: Commercial" for all SCCs.

Table 4-139: Asphalt Paving SCCs estimated by EPA and S/L/Ts

SCC	Description	EPA	State	Local	Tribe
2461020000	Asphalt Application: All Processes; Total: All Solvent Types		X		
2461021000	Cutback Asphalt; Total: All Solvent Types	X	X	X	X
2461022000	Emulsified Asphalt; Total: All Solvent Types	X	X	X	X

The agencies listed in Table 4-140 submitted VOC emissions for cutback and/or emulsified asphalt paving; agencies not listed used EPA estimates for the entire sector.

Table 4-140: Percentage of cutback and emulsified Asphalt Paving VOC emissions submitted by reporting agency

Region	Agency	S/L/T	SCC	Description	VOC
2	New Jersey Department of Environment Protection	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
3	Delaware Department of Natural Resources and Environmental Control	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
3	Maryland Department of the Environment	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
3	Virginia Department of Environmental Quality	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
5	Illinois Environmental Protection Agency	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
5	Michigan Department of Environmental Quality	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
5	Minnesota Pollution Control Agency	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
6	Texas Commission on Environmental Quality	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	Tribe	2461021000	Cutback Asphalt; Total: All Solvent Types	100
8	Utah Division of Air Quality	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
9	California Air Resources Board	State	2461021000	Cutback Asphalt; Total: All Solvent Types	64
9	Maricopa County Air Quality Department	Local	2461021000	Cutback Asphalt; Total: All Solvent Types	100
9	Washoe County Health District	Local	2461021000	Cutback Asphalt; Total: All Solvent Types	100
10	Coeur d'Alene Tribe	Tribe	2461021000	Cutback Asphalt; Total: All Solvent Types	100
10	Idaho Department of Environmental Quality	State	2461021000	Cutback Asphalt; Total: All Solvent Types	100
10	Kootenai Tribe of Idaho	Tribe	2461021000	Cutback Asphalt; Total: All Solvent Types	100
10	Nez Perce Tribe	Tribe	2461021000	Cutback Asphalt; Total: All Solvent Types	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	2461021000	Cutback Asphalt; Total: All Solvent Types	100
1	New Hampshire Department of Environmental Services	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
2	New Jersey Department of Environment Protection	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
3	Delaware Department of Natural Resources and Environmental Control	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
3	Maryland Department of the Environment	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
3	Virginia Department of Environmental Quality	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100

Region	Agency	S/L/T	SCC	Description	VOC
5	Illinois Environmental Protection Agency	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
5	Michigan Department of Environmental Quality	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
5	Minnesota Pollution Control Agency	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
6	Texas Commission on Environmental Quality	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
8	Utah Division of Air Quality	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
9	California Air Resources Board	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	94
9	Maricopa County Air Quality Department	Local	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
9	Washoe County Health District	Local	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
10	Coeur d'Alene Tribe	Tribe	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
10	Idaho Department of Environmental Quality	State	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
10	Kootenai Tribe of Idaho	Tribe	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
10	Nez Perce Tribe	Tribe	2461022000	Emulsified Asphalt; Total: All Solvent Types	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	2461022000	Emulsified Asphalt; Total: All Solvent Types	100

4.22.3 EPA-developed emissions for asphalt paving: unchanged for the 2014v2 NEI

Additional information about asphalt paving practices and terminology is provided in the nonpoint asphalt paving method development document "*2014_NPt_Asphalt_18nov2015_edit03302016.zip*" on the 2014v1 Supplemental Data FTP site.

EPA estimated emissions from paving processes that use cold mix asphalt – cutback and emulsified, but not from the use of hot mix asphalt or WMA. For the 2014 NEI v1, the EPA could not find readily available information on the composition of HMA asphalt binder or from WMA products. Emission estimates from HMA/WMA paving are not provided at this time.

4.22.3.1 *Activity data*

The EPA's pre-existing emissions estimation method for paving using cutback or emulsified asphalt cement applies 2008 usage data by the Asphalt Institute. The 2008 usage data for cutback and emulsified asphalt is also applied for the 2014 NEI v1. General on-line data searches did not yield more recent and available information on cutback and emulsified asphalt usage though data may be available for purchase from Freedonia. Several information sources indicate that the Asphalt Institute which performed periodic surveys through 2008, stopped surveys efforts of that type after 2008. The EPA contacted the Asphalt Institute to see if more recent activity data is available and was provided the copyright protected 2014 survey report. While that data is not presented here, review indicated little difference between the national-level 2008 and the 2014 use amounts for cutback asphalt and a larger increase in the national 2014 emulsified usage compared to the 2008 use value, i.e., a 20 percent change from 2008. The Asphalt Institute 2008 survey indicated many states had zero usage for cutback asphalt- specifically AK, CT, DE, DC, HI, ME, MD, MA, NH, NJ, NY, NC, RI, SC, VT, and WV. Some of those states also were noted with zero usage for emulsified asphalt. Based on comparison of the 2008 activity with the MANE-VU 2007 inventory [ref 3] and the 2011v2 NEI, it appears that the proposed estimates for the 2014 NEI asphalt emissions may under-estimate (zero out emissions) for the MARAMA states when many of those states have emissions in the 2007 MANE-VU inventory and in the 2011 NEI v2. The use of 2008 activity data as a surrogate for the 2014 NEI likely under-estimates some states' use of cutback and emulsified asphalts, and perhaps more so for emulsified. The survey report acknowledged that manufacturers or resellers in some states may have not reported or under-reported due to confidentiality concerns.

The rate of growth pattern for asphalt use between 2008 and 2014 was also reviewed by looking at several on-line sources such as Freedonia brochures [ref 4] and, as seen in Figure 4-21, the U.S. Energy Information Administration (EIA) State Energy Data System (SEDS) [ref 5]. Freedonia suggests that demand for asphalt in the United States will rebound from the sharp declines in the 2007-2012 period, driven by stronger economic growth and increased construction activity, though demand in 2017 is expected to remain below the 2007 level. The US and Canada are significant consumers of asphalt for roofing products; demand for those products will rise with increased building construction expenditures. The study says demand for asphalt in both paving and roofing applications will be driven by the recovering US economy and increasing construction activity in the country. Review of the EIA SEDs data to determine the trend in asphalt product sales and consumption since 2008, specifically the petroleum end-use industrial sector of asphalt and road oil - indicates that state-level consumption (see Figure 4-22) of asphalt and road oil between the years of 2008-2013 experienced a general decline or approximately flat growth.

Figure 4-21: EIA-based U.S. asphalt road oil consumption estimates

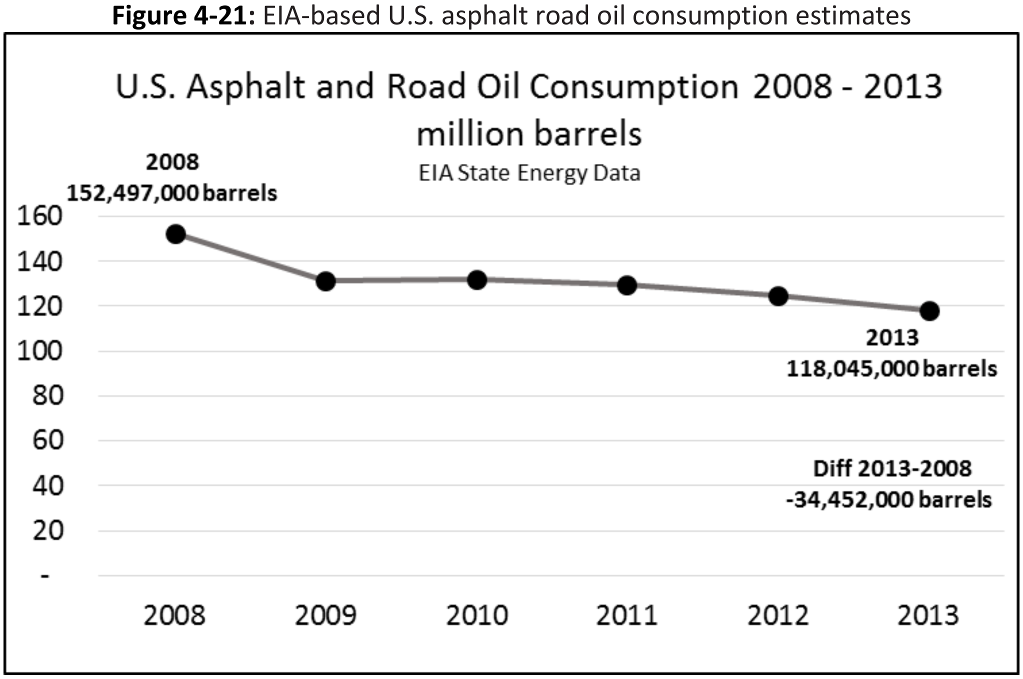
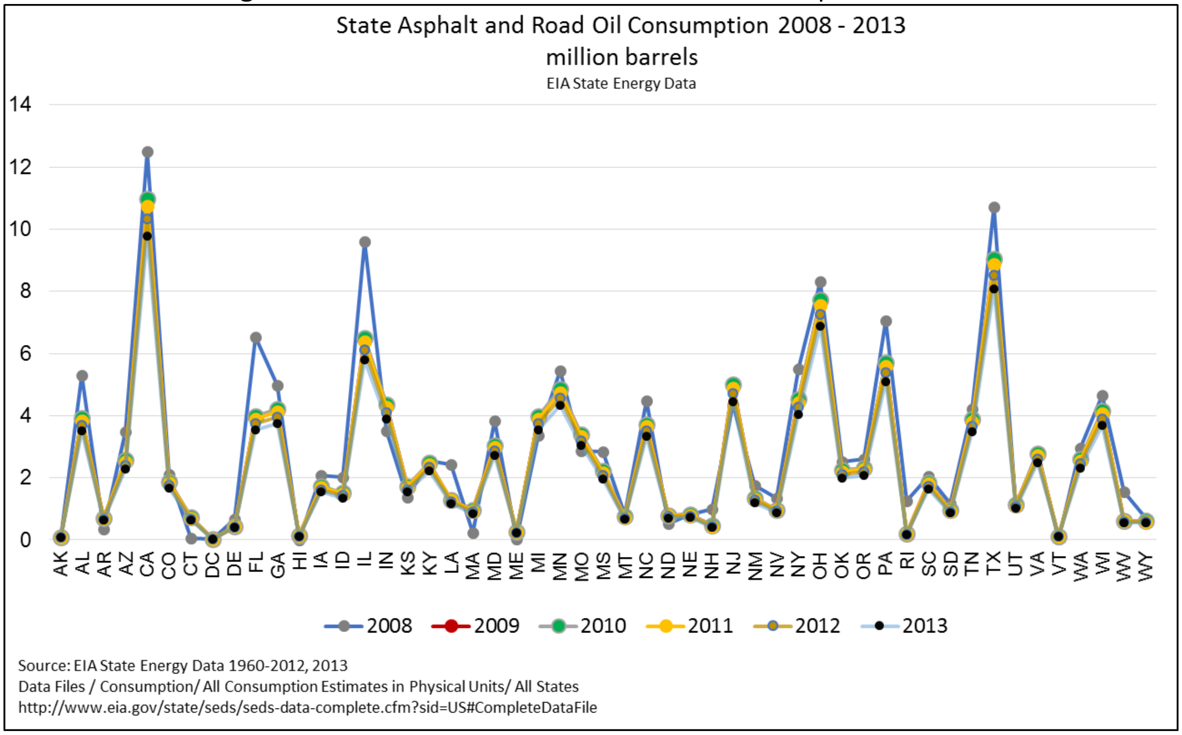


Figure 4-22: EIA-based state-level road oil consumption trends



The FHWA (Federal Highway Administration) is also a potential source of activity data via their contract with the National Paving Association to survey states about their use of asphalt and reclaimed materials. The FWHA and National Paving Association survey of 2013 [ref 6] state-level asphalt usage cites an increased use of warm-mix asphalt and recycled content. *There is no discussion however of the binder composition or the amount of solvent that may be attributed to the HMA (hot-mix) or WMA.* The objective of the survey was to quantify the use of recycled materials and WMA produced by the asphalt pavement industry in each state. The results include an estimate of 351 million tons of HMA/WMA plant mix asphalt produced in 2013, of which WMA is 106 million tons. While the 2008 data usage indicated some states with zero use of cutback and emulsified asphalt for paving, there are no states with an estimated zero HMA/WMA asphalt production for 2013.

Additional discussion and review of the activity data is provided in the nonpoint asphalt paving method development document "*2014_NPt_Asphalt_18nov2015_edit03302016.zip*" on the [2014v1 Supplemental Data FTP site](). That discussion includes a comparison of the 2008 *usage* for cutback and emulsified asphalt that EPA last obtained from the Asphalt Institute with the state summary of HMA/WMA asphalt *production* for 2013.

Many state and or local jurisdictions restrict or ban the use of highly evaporative asphalt mixtures such as cutback asphalt during months of potentially poor air quality, i.e., typically in the warmer, sunny months. Paving using cutback asphalt may be scheduled and resume in other parts of the year when evaporation of the VOC content will not influence ozone formation as much. For the purposes of the NEI annual county-level estimate, it may be assumed that the county allocation of asphalt usage will eventually be used at some point during the year, rather than assuming emissions are 'zeroed-out' – unless bans are in place. If agencies are developing an inventory for SIP purposes, a monthly inventory could be calculated to account for monthly variations in process activity, unless restricted use or bans. EPA's processing of the annual emission inventory for regional air quality modeling may not take that into account unless county, SCC-specific spatial and temporal factors can be developed and applied, which is typically outside of the scope of limited resources unless the SCC emissions are particularly significant relative to other emission sources. Table 4-141 summarizes the activity data applied and the sources.

Table 4-141: Sources of activity data and related parameters, where G=given and C=computed

	Parameter	Source Reference Use Note
G	Quantity of asphalt used by state, by asphalt type – cutback, emulsified Annual 2008 national tons	2008 Asphalt Usage Survey, purchased from Asphalt Institute The state-level 2008 activity was used for the 2008 and the 2011 NEI. This asphalt use is assumed to be for asphalt cement, rather than for asphalt concrete which is composed of both aggregate (~95% by weight) and asphalt cement (~5%by weight).
G	State $VMT_{2013\ FHWA\ Roads}$	State-level annual vehicle miles traveled (VMT) by FHWA road class, 2013. FHWA Report VM-2, 2013 [ref 7].
C	County $VMT_{FHWA\ Roads\ for\ 2014\ NEI}$	Estimate of county-level annual VMT by FHWA road class, for 2014 NEI. This approximation of county-level annual VMT for 2014 is based on the equation: County $VMT_{FHWA\ Road\ Type\ for\ 2014\ NEI}$ = 2011NEIv2 $CountyVMT_{MOVES\_NEI\ Road\ Type}$ x (2013 $StateVMT_{FHWA\ Road\ Type}$ /2013 State $_{MOVES\_NEI\ Road\ Type}$) See EIAG's NEI documentation file: <README_VMTfor2014NEInptCals_20150728.docx>
C	County VMT fraction of State VMT	Estimate of county fraction of the state VMT by FHWA road class, for 2014 NEI. This approximation is based on the equation: (2014 County $VMT_{FHWA\ Road}$ / 2013 State $VMT_{FHWA\ Road}$) = $(County\ VMT/\ State\ VMT)_{FHWA\ Road\ for\ 2014\ NEI}$
G	State $Lane\text{-}Miles_{2013\ FHWA\ Roads}$	State lane-miles by FHWA road class, 2013. FHWA Report HM-60, 2013.
G	State Paved Road $Miles_{2013\ FHWA\ Roads}$	State paved road miles by FHWA road class, 2013. FHWA Report HM-51, 2013.
C	State Paved $Lane\text{-}Miles_{2013\ FHWA\ Roads}$	Estimate of state lane-miles that are paved by FHWA road class, for 2013 based on the equation: [state paved road $miles_{2013\ FHWA\ Road}$ / (state paved + unpaved road $miles)_{2013\ FHWA\ Road}$] x state $lane\text{-}miles_{2013\ FHWA\ Road}$ = state paved $lane\text{-}miles_{2013\ FHWA\ Road}$
C	State Utilization $Paved_{2013\ FHWA\ Roads}$	Estimate of state-level utilization measure for paved road surface by FHWA road class, for 2013 based on the equation: ($stateVMT_{2013\ FHWA\ Road}$ /state paved $lane\text{-}miles_{2013\ FHWA\ Road}$) = state utilization paved $roads_{2013\ FHWA\ Road}$
C	County Utilization $Paved_{2013\ FHWA\ Roads}$	Estimate of the county-level utilization measure for paved road surface by FHWA road class is calculated by applying the county/state VMT fraction to the state paved road utilization measure. $(county\ VMT/\ state\ VMT)_{FHWA\ Road\ for\ 2014\ NEI}$ x (state utilization paved $roads_{2013\ FHWA\ Road}$) = county utilization paved $roads_{2013\ FHWA\ road}$
C	County Utilization Sum_{2013} County-to-State Utiliz Sum_{2013}	Sum the county utilization by FHWA roads to county total and sum the county totals to state total.
C	County Utilization Fraction of State Utilization	Estimate of county fraction of the state utilization measure for paved road surface is based on the equation: (county utilization $paved_{2013}$/ CountyToStateSum utilization $paved_{2013}$)

	Parameter	Source Reference Use Note
C	County Asphalt Usage for 2014NEI	County-level cutback asphalt usage estimated by allocating state-level usage data to county based on the estimate of county utilization paved $roads_{2013}$ using the equation: (state-level asphalt usage x (county utilization $paved_{2013}$/ CountyToStateSum utilization $paved_{2013}$) = county asphalt usage for 2014NEI

Distribution of Activity Data to the County

While the 2008 asphalt usage from the pre-existing method was applied again for the 2014 NEI v1, the procedure for distributing the state asphalt use to county-level usage was updated with the intent to simplify the method by using ready available FHWA data reports to develop a utilization measure for paved roads. The utilization measure focuses on the quantity of travel on paved roads. The pre-existing EPA distribution procedure applies 10+ year old FHWA data no longer published concerning traffic volume with conversion to VMT (vehicle miles travelled) using assumed speeds. The intent of the update was to develop a state-to-county activity distribution factor that is computationally more stream-lined, requires less operating assumptions, and uses current and routinely available FHWA highway statistics reports rather than carry forward and build a factor upon old data (1996) as a surrogate for information no longer published (HM-67 Miles by Surface Type and Average Daily Traffic Volume Group, last published in 1997). The update also intends to allocate paving to areas with the highest travel. This isn't a perfect methodology as all roads get paved at some point in time, even low-usage rural roads on their own maintenance schedule, but it may be a reasonable approximation.

The update considers the following performance measures and definitions that may be applied by state DOTs and MPOs [ref 8].

Dimension	Performance Measure	Definition
Quantity of Travel	Vehicle miles traveled	Average Annual Daily Traffic * Length
Utilization	Vehicles per lane-mile	Average Annual Daily Traffic * Length/lane miles

The operating assumption is that the county-level paved road utilization is similar to the calculated state-level paved road utilization measure, and may be related based on the county VMT fraction of state VMT. The general steps using the activity parameters in the above Table are as follows.

- Step 1. Develop state road utilization measure by road surface.
  Utilization measure = VMT/ lane-miles.
  By FHWA road type, the amount of lane-miles that are paved may be expressed as: (state paved road miles/ state paved + unpaved road miles) x state lane-miles = state paved lane-miles.
  State utilization measure for paved road surface = (state VMT / (state paved lane-miles)
- Step 2. Compute county-to-state fraction for quantity of travel, i.e., vehicle miles traveled.
  By FHWA road type, the county-to-state fraction, vehicle miles traveled = County VMT/ State VMT.
  Estimate of annual county VMT based on MOVES mobile source model is provided by EPA.
- Step 3. Compute county-level utilization measure for paved roads.
  By FHWA road type, apply the county/state VMT fraction (Step 2) to the state road utilization measure by paved road type (Step 1) to obtain the county-level road utilization measure for paved roads.
  County utilization paved roads = (County VMT/state VMT) x (State utilization measure for paved road surface)

- Step 4. Sum the county utilization by FHWA roads to county total and sum the county totals to state total.
- Step 5. Estimate the county fraction of the state utilization measure for paved road surface as: County utilization paved roads / county-to-state sum utilization paved

The county fraction of state utilization measure computed in step 5 is multiplied by the state asphalt usage to distribute the state-level asphalt use to county usage.

4.22.3.2 *Emission Factors*

The annual mass emission rate factors for cutback and emulsified asphalt are updated using the 2008 asphalt consumption data and MSDS (Material Safety Data Sheets) information to reflect the composition of cutback and emulsified paving mixtures used today. Table 4-142 summarizes the sources of emission factors and related parameters.

Table 4-142: Sources of emission factors and related parameters, where G=given and C=computed

	Parameter	**Source Reference Use Notes**
C	Emission Factor VOC, HAPs	Emission factors are updated for 2014 NEI. Basis includes: 2008 annual asphalt cement use data from Asphalt Institute; average chemical composition information from available online MSDS – specific diluent, % weight fraction; and assumed %weight emitted. See factors in Table 4-143 and equations in method discussion section.
G	Asphalt cement consumption Annual 2008 national tons	The 2008 activity usage by state (2008 Asphalt Usage Survey, from Asphalt Institute) is summed to national. Cutback usage = 187,328 tons; Emulsified usage = 1,350,999 tons.
G	Diluent(s) and Average pct of each diluent in asphalt cement	Determination that likely multiple diluents are present in asphalt cement (binder) and an average weight percent of diluent in asphalt cement is assumed based on MSDS information. Specific diluent and properties are referenced in method discussion section.
G	Density of asphalt	The density of asphalt is assumed similar to that of water, 8.34 lbs/gal which seems reasonable based on relative density information in MSDS.
G	Density of diluent (s)	Density measures for each diluent are referenced in method discussion section. While density measures were gathered/recorded, they are not used for weight % calculations.
G	Pct by wgt of volatile (diluent) emitted in product	95% of total solvent is assumed emitted; with 5% of total solvent assumed retained in the product.
C	Emissions	Emissions = County-Level Asphalt Usage * Emission Factors

Emission factors (lbs pollutant emitted/ ton asphalt, cutback or emulsified) were calculated using parameters in the above table:

- lbs/yr cutback (or emulsified) cement x avg % weight diluent = lbs/yr diluent
- lbs/yr diluent x avg weight % volatile emitted = lbs/yr diluent emitted
- annual mass emission rate: (lbs poll emitted/yr) / (tons asphalt used/yr) = lb/ton

Material Safety Data Sheets (MSDS) for cutback and emulsified asphalt were searched on-line and reviewed as a general way to assess the physical parameters used in the pre-existing emission factor calculation – regarding material composition, percent concentrations, and density measures. The MSDS typically cover a range of graded asphalts and note that petroleum asphalt is mixed with varying proportions of solvent, fuel oils, kerosene, and/or petroleum residues and the composition varies depending on source of crude and specifications of final product. Information from several MSDS are summarized below. Based on the MSDS information, the following values, seen in Table 4-143, were developed and applied as average composite surrogates. The information for cutback is based primarily on rapid cure though ethylbenzene is cited for presence in medium and slow cure mixtures. In the MSDS, the units of the concentration percent is seldom confirmed as whether percent by volume or percent by weight. When it was specified on the emulsified and cutback sheets reviewed, it was percent by weight. References for several ASTM (American Society for Testing and Materials) standard methods for sampling and testing the composition of bituminous paving materials were reviewed to form the assumption that the concentration percentages are mass percentages.

Additional information, including the use of specific MSDS, is provided in the nonpoint asphalt paving method development document "*2014_NPt_Asphalt_18nov2015_edit03302016.zip*" on the 2014v1 Supplemental Data FTP site.

Table 4-143: Cutback asphalt computed average chemical composition information

Chemical Composition, i.e., VOCs, HAPs	Avg % by Weight	Density	Note
Asphalt	60-90	8.34 lb/gal	Relative Density ~ 0.9-.99, water=1
Naptha, i.e., VM&P, Stoddards solv	40	6.3 lb/gal	15C/60F (CDC/NIOSH)
Naphthalene	0.49 (0.58 w PAH)	9.5 lb/gal	20C/68F (CDC/NIOSH), SG 1.16
Toluene	0.59	7.2 lb/gal	20C/68F (CDC/NIOSH)
Xylene	0.99	7.2 lb/gal	20C/68F (CDC/NIOSH)
Benzene	0.19	7.3 lb/gal	20C/68F (CDC/NIOSH)
Ethylbenzene	0.49	7.2 lb/gal	20C/68F (CDC/NIOSH)
Polycyclic Aromatic Hydrocarbons	0.09		Add to weight % as naphthalene
Hydrogen Sulfide	0.09	8.3 lb/ gal	SG 1.19 (gas)

The units of the updated emission factors, seen in Table 4-144 are different than for the pre-existing factors. A conservative conversion of the existing lbs/ barrel value to terms of lbs/ton is done using the conversion factor: 5.5 barrels of road oil / ton [ref 4].

Table 4-144: Updated emission factors and expected pollutants by SCC vs. pre-existing factors

SCC	Description	Pollutant	Pollutant Code	Update lb/ton	Pre-existing lb/barrel
2461021000	Cutback Asphalt, Total: All Solvent Types	VOC	VOC	813.96	88.0
		Benzene	71432	3.6	
		Ethylbenzene	100414	9.3	2.02
		Naphthalene	91203	11.0	
		Toluene	108883	11.2	5.63
		Xylenes (Mixed Isomers)	1330207	18.8	10.74
		Hydrogen Sulfide	7783064	1.7	
2461022000	Emulsified All	VOC	VOC	195.5	9.2

SCC	Description	Pollutant	Pollutant Code	Update lb/ton	Pre-existing lb/barrel
	Asphalt, Total: Solvent Types	Naphthalene	91203	5.5	
		Hydrogen Sulfide	7783064	1.7	

Example: 88 lbs VOC/ barrel x 5.5 barrels/ton = 484 lb VOC/ ton

The updated emission factors include (three) additional HAPs (hazardous air pollutants) based on review of some current available MSDS composition information. The pre-existing HAP factors were based on a percent weight of VOC from the EPA 1996 NTI (National Toxics Inventory).

The nonpoint asphalt paving method development document "*2014_NPt_Asphalt_18nov2015_edit03302016.zip*" on the 2014v1 Supplemental Data FTP site includes a discussion of the basis for the pre-existing emission factors and the specific calculations for the updated factors.

4.22.3.3 *Some Possible Steps for Further Improvement in the 2017 NEI*

The method updates for the 2014v1 NEI involved contacting the FHWA, the Asphalt Institute, and the NAPA. FHWA staff responded that they do not collect nor track information on cutback and emulsified asphalt usage on the National Highway System and that emulsions are generally used in maintenance activities and not new construction or re-construction. Staff from the Asphalt Institute responded to provide their copyright protected 2014 survey report with request that it not be further distributed. As of this writing, response was not received from the NAPA.

FHWA may be able to obtain information from their paving industry partners, i.e., NAPA to help quantify the composition of WMA and HMA. For HMA and WMA, knowing the use amounts that may include solvents with evaporative potential and also whether there are amounts of cutback and emulsified not covered by their annual survey purposes, could improve both activity and composition information to update the emission factor calculations. NAPA also conducts FHWA co-sponsored research of which on-line brochure indicates that NAPA drafted a report [ref 8] comparing criteria air pollutant emissions of warm-mix technologies and hot-mix technologies - available upon request from NAPA and that the report was not released to the public because additional stack emissions testing is needed to determine the extent of criteria air pollutant reduction with the use of warm-mix technologies. Current asphalt use (activity) data may also be available for purchase from Freedonia.

More in-depth on-line literature searches, e.g., Science Direct, could also be conducted to see if research results exist that describe measured volatile composition of asphalt mixtures used today. That could be another way to further assess emission characteristics of the VOC and individual chemical species.

The nonpoint asphalt paving method development document "*2014_NPt_Asphalt_18nov2015_edit03302016.zip*" on the 2014v1 Supplemental Data FTP site includes a list of some possible contacts for more information.

4.22.4 References for asphalt paving

1. Wisconsin Transportation Bulletin • No. 1, Understanding and Using Asphalt
2. National Cooperative Highway Research Program (NCHRP) Report 673. A Manual for Design of Hot Mix Asphalt with Commentary. 2011
3. MARAMA, 2011. 2007/2017/2020 Modeling Emissions Inventory Version 2 Preliminary Trends Analysis.
4. Freedonia Brochure – Asphalt Paving.

5. EIA SEDS, Prices and Expenditures, Petroleum Overview, accessed 2015.
6. Annual Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage: 2009–2013. Information Series 138. National Asphalt Paving Association.
7. FHWA Traffic Analysis Toolbox Volume VI: Definition, Interpretation, and Calculation of Traffic Analysis Tools Measures of Effectiveness (MOEs), Tables 6 and 7.
8. National Asphalt Pavement Association Research Project Summary Brochure 2015.

4.23 Solvents: All other Solvents

This section includes discussion on all nonpoint solvent sources except for agricultural pesticide application (see Section 4.21) and asphalt paving (see Section 4.22). The reason these sources are discussed separately is because the EPA methodologies for estimating the emissions are different.

4.23.1 Sector description

Solvent usage is covered in the NEI for 2014 by many SCCs and is comprised of industrial, commercial, and residential applications. EPA's solvents category includes architectural surface coatings, industrial surface coatings, degreasing, graphic arts, dry cleaning, consumer and commercial (includes personal care products and household products), automotive aftermarket, adhesives and sealants, and FIFRA related products (pesticides).

4.23.2 Sources of data

Table 4-145 shows, for Solvents, the nonpoint SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 2, 3 and 4 SCC descriptions are also provided. The SCC level 1 description is "Solvent Utilization" for all SCCs. Note that the SCCs in this list are only the SCCs that either the EPA used or the submitting State agencies used in the 2014 NEI, and not a comprehensive list of all "active" Solvent SCCs. Also note the solvent SCCs (see table footnote) that were discussed in previous sections.

Table 4-145: Nonpoint Solvent SCCs with 2014 NEI emissions

SCC	Description	EPA	State	Local	Tribe	Sector
2401001000	Surface Coating; Architectural Coatings; Total: All Solvent Types	X	X	X	X	Solvent - Non-Industrial Surface Coating
2401001050	Surface Coating; Architectural Coatings; All Other Architectural Categories		X			Solvent - Non-Industrial Surface Coating
2401005000	Surface Coating; Auto Refinishing: SIC 7532; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401005700	Surface Coating; Auto Refinishing: SIC 7532; Top Coats		X			Solvent - Industrial Surface Coating & Solvent Use
2401005800	Surface Coating; Auto Refinishing: SIC 7532; Clean-up Solvents		X			Solvent - Industrial Surface Coating & Solvent Use
2401008000	Surface Coating; Traffic Markings; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401010000	Surface Coating; Textile Products: SIC 22; Total: All Solvent Types		X			Solvent - Industrial Surface Coating & Solvent Use

SCC	Description	EPA	State	Local	Tribe	Sector
2401015000	Surface Coating; Factory Finished Wood: SIC 2426 thru 242; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401020000	Surface Coating; Wood Furniture: SIC 25; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401025000	Surface Coating; Metal Furniture: SIC 25; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401030000	Surface Coating; Paper: SIC 26; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401035000	Surface Coating; Plastic Products: SIC 308; Total: All Solvent Types		X	X		Solvent - Industrial Surface Coating & Solvent Use
2401040000	Surface Coating; Metal Cans: SIC 341; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401045000	Surface Coating; Metal Coils: SIC 3498; Total: All Solvent Types		X		X	Solvent - Industrial Surface Coating & Solvent Use
2401050000	Surface Coating; Miscellaneous Finished Metals: SIC 34 - (341 + 3498); Total: All Solvent Types		X			Solvent - Industrial Surface Coating & Solvent Use
2401055000	Surface Coating; Machinery and Equipment: SIC 35; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401060000	Surface Coating; Large Appliances: SIC 363; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401065000	Surface Coating; Electronic and Other Electrical: SIC 36 - 363; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401070000	Surface Coating; Motor Vehicles: SIC 371; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401075000	Surface Coating; Aircraft: SIC 372; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401080000	Surface Coating; Marine: SIC 373; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401085000	Surface Coating; Railroad: SIC 374; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401090000	Surface Coating; Miscellaneous Manufacturing; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401100000	Surface Coating; Industrial Maintenance Coatings; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use
2401200000	Surface Coating; Other Special Purpose Coatings; Total: All Solvent Types	X	X	X	X	Solvent - Industrial Surface Coating & Solvent Use

SCC	Description	EPA	State	Local	Tribe	Sector
2415000000	Degreasing; All Processes/All Industries; Total: All Solvent Types	X	X	X	X	Solvent - Degreasing
2420000000	Dry Cleaning; All Processes; Total: All Solvent Types	X	X	X	X	Solvent - Dry Cleaning
2425000000	Graphic Arts; All Processes; Total: All Solvent Types	X	X	X	X	Solvent - Graphic Arts
2440000000	Miscellaneous Industrial; All Processes; Total: All Solvent Types		X	X		Solvent - Industrial Surface Coating & Solvent Use
2440020000	Miscellaneous Industrial; Adhesive (Industrial) Application; Total: All Solvent Types		X			Solvent - Industrial Surface Coating & Solvent Use
2460000000	Miscellaneous Non-industrial: Consumer and Commercial; All Processes; Total: All Solvent Types		X			Solvent - Consumer & Commercial Solvent Use
2460100000	Miscellaneous Non-industrial: Consumer and Commercial; All Personal Care Products; Total: All Solvent Types	X	X	X	X	Solvent - Consumer & Commercial Solvent Use
2460140000	Miscellaneous Non-industrial: Consumer and Commercial: Personal Care Products: Powders: Total: All Solvent Types		X			Solvent - Consumer & Commercial Solvent Use
2460200000	Miscellaneous Non-industrial: Consumer and Commercial; All Household Products; Total: All Solvent Types	X	X	X	X	Solvent - Consumer & Commercial Solvent Use
2460400000	Miscellaneous Non-industrial: Consumer and Commercial; All Automotive Aftermarket Products; Total: All Solvent Types	X	X	X	X	Solvent - Consumer & Commercial Solvent Use
2460500000	Miscellaneous Non-industrial: Consumer and Commercial; All Coatings and Related Products; Total: All Solvent Types	X	X	X	X	Solvent - Consumer & Commercial Solvent Use
2460600000	Miscellaneous Non-industrial: Consumer and Commercial; All Adhesives and Sealants; Total: All Solvent Types	X	X	X	X	Solvent - Consumer & Commercial Solvent Use
2460800000	Miscellaneous Non-industrial: Consumer and Commercial; All FIFRA Related Products; Total: All Solvent Types	X	X	X	X	Solvent - Consumer & Commercial Solvent Use

SCC	Description	EPA	State	Local	Tribe	Sector
2460900000	Miscellaneous Non-industrial: Consumer and Commercial; Miscellaneous Products (Not Otherwise Covered); Total: All Solvent Types	X	X	X	X	Solvent - Consumer & Commercial Solvent Use
2461000000	Miscellaneous Non-industrial: Commercial; All Processes; Total: All Solvent Types			X		Solvent - Consumer & Commercial Solvent Use
2461020000*	Miscellaneous Non-industrial: Commercial; Asphalt Application: All Processes; Total: All Solvent Types		X			Solvent - Consumer & Commercial Solvent Use
2461021000*	Miscellaneous Non-industrial: Commercial; Cutback Asphalt; Total: All Solvent Types	X	X	X	X	Solvent - Consumer & Commercial Solvent Use
2461022000*	Miscellaneous Non-industrial: Commercial; Emulsified Asphalt; Total: All Solvent Types	X	X	X	X	Solvent - Consumer & Commercial Solvent Use
2461023000	Miscellaneous Non-industrial: Commercial; Asphalt Roofing; Total: All Solvent Types		X			Solvent - Consumer & Commercial Solvent Use
2461024000	Miscellaneous Non-industrial: Commercial; Asphalt Pipe Coating; Total: All Solvent Types		X			Solvent - Consumer & Commercial Solvent Use
2461160000	Miscellaneous Non-industrial: Commercial; Tank/Drum Cleaning: All Processes; Total: All Solvent Types		X			Solvent - Consumer & Commercial Solvent Use
2461800001*	Miscellaneous Non-industrial: Commercial; Pesticide Application: All Processes; Surface Application		X			Solvent - Consumer & Commercial Solvent Use
2461800002*	Miscellaneous Non-industrial: Commercial; Pesticide Application: All Processes; Soil Incorporation		X			Solvent - Consumer & Commercial Solvent Use
2461850000*	Miscellaneous Non-industrial: Commercial; Pesticide Application: Agricultural; All Processes	X	X		X	Solvent - Consumer & Commercial Solvent Use
2461900000	Miscellaneous Non-industrial: Commercial: Miscellaneous Products: NEC: Total: All Solvent Types		X			Solvent - Consumer & Commercial Solvent Use

* These sources are discussed in Section 4.21 (Agricultural Pesticides) and Section 4.22 (Asphalt Paving)

The agencies listed in Table 4-146 submitted at least VOC emissions for all the EIS Solvent sectors discussed in this section: Consumer & Commercial Use, Degreasing, Dry Cleaning, Graphic Arts, Industrial Surface Coating &

Solvent Use, and Non-Industrial Surface Coating. Agencies not listed used EPA estimates for the entire sector. Some agencies submitted emissions for the entire sector (100%), while others submitted only a portion of the sector (totals less than 100%).

Table 4-146: EIS sector-specific percentage of Solvent VOC emissions submitted by reporting agency

Region	Agency	S/L/T	Consumer/ Commercial	Degreasing	Dry Cleaning	Graphic Arts	Ind. Sfc. Coat + Solv. Use	Non-Ind. Sfc. Coating
1	Connecticut Department of Energy and Environmental Protection	State	100	100	100	100	100	100
1	Maine Department of Environmental Protection	State	98	100	100	100	100	100
1	Massachusetts Department of Environmental Protection	State		100	100	100	100	100
1	New Hampshire Department of Environmental Services	State	18	100		100	77	100
1	Rhode Island Department of Environmental Management	State		100		98	35	
2	New Jersey Department of Environment Protection	State	100	100	100	100	100	100
2	New York State Department of Environmental Conservation	State	95	100	100	100	100	100
3	DC-District Department of the Environment	Local	99	100	100	100	100	100
3	Delaware Department of Natural Resources and Environmental Control	State	100	100	100	100	100	100
3	Maryland Department of the Environment	State	94	99	100	100	98	100
3	Pennsylvania Department of Environmental Protection	State	74	100		100	100	100
3	Virginia Department of Environmental Quality	State	96	100		100	90	100
3	West Virginia Division of Air Quality	State	94	100	100	100	100	100
4	Chattanooga Air Pollution Control Bureau (CHCAPCB)	Local	86	100	100	100	100	100
4	Florida Department of Environmental Protection	State	77	100	100	100	100	100
4	Georgia Department of Natural Resources	State		100	100		75	
4	Knox County Department of Air Quality Management	State	85	100	100	100	100	100
4	Louisville Metro Air Pollution Control District	Local	88	100	100		48	100
4	Metro Public Health of Nashville/Davidson County	Local	50		100		18	100
4	South Carolina Department of Health and Environmental Control	State	91	100	100	100	100	100
5	Illinois Environmental Protection Agency	State	100	100	100	100	100	100
5	Indiana Department of Environmental Management	State		100			58	
5	Michigan Department of Environmental Quality	State	94	100	100	100	100	100
5	Minnesota Pollution Control Agency	State	83	100	100	99	100	100
5	Ohio Environmental Protection Agency	State	88	100		100	100	100
5	Wisconsin Department of Natural Resources	State	76	100			100	100

Region	Agency	S/L/T	Consumer/ Commercial	Degreasing	Dry Cleaning	Graphic Arts	Ind. Sfc. Coat + Solv. Use	Non-Ind. Sfc. Coating
6	Louisiana Department of Environmental Quality	State	88	100	100	100	100	100
6	Oklahoma Department of Environmental Quality	State	73	100	100	100	100	100
6	Texas Commission on Environmental Quality	State	95	100	100	100	100	100
7	Iowa Department of Natural Resources	State	55	100	100	100	100	100
7	Kansas Department of Health and Environment	State	63	100	100	100	100	100
7	Missouri Department of Natural Resources	State		100		100	35	
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	100					
8	Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation	Tribe	100					
8	Northern Cheyenne Tribe	Tribe	100					100
8	Utah Division of Air Quality	State	80	100	100	100	100	100
9	Arizona Department of Environmental Quality	State	72	100	100	100	100	100
9	California Air Resources Board	State	94	100	4	16	64	6
9	Clark County Department of Air Quality and Environmental Management	Local					0	
9	Maricopa County Air Quality Department	Local	9	100		100	6	100
9	Washoe County Health District	Local	55	100	100	100	61	100
10	Coeur d'Alene Tribe	Tribe	100	100	100	100	100	100
10	Idaho Department of Environmental Quality	State	100	100	100	100	100	100
10	Kootenai Tribe of Idaho	Tribe	100	100			100	100
10	Nez Perce Tribe	Tribe	100	100	100	100	100	100
10	Oregon Department of Environmental Quality	State	67	100	100	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100	100	100	100	100	100

* The EIS sector Consumer & Commercial EIS includes agricultural pesticide application and asphalt paving, sources discussed in previous sections.

4.23.3 EPA-developed emissions from the Solvent Tool, new for 2014v2

New for 2014 is a MS Access tool which calculates emissions for almost all the solvent categories estimated by EPA. More information on the solvents tool can be found in the documentation entitled, "Solvent Tool Documentation v1_7," found in "Solvent_Tool_v1.7.zip"on the 2014v2 Supplemental Nonpoint data FTP site. There are three SCCs that are highlighted in Table 4-145 that EPA estimates and are not covered by the MS Access Tool, which include Agricultural Pesticide Application and Cutback and Emulsified Asphalt Paving.

The benefits of consolidating the solvent categories into MS Access are twofold. Activity data can be a common thread amongst many of these SCCs, eliminating the need to upload data repeatedly to many different MS Excel workbooks. Also, the tool can export final emissions data to staging table format, making uploading final emissions data to EIS easier and less of a burden to EIS data submitters.

In general, the solvent tool uses activity factors that are based either on employment or population, with a notable exception of Lane Miles for Traffic Marking applications. Most point source data do not rely on these same activity inputs, which makes conducting point source subtraction on an activity basis difficult. Therefore, the tool was developed to accept point source data for subtraction in two ways: either activity or an emissions Point/Nonpoint SCC Crosswalk.

In addition, much work was done to improve the point/nonpoint crosswalk, so that point source subtraction could be done within the tool. The crosswalk was updated with the addition of approximately 65 SCCs.

States were given the option to accept EPA estimates. However, this premise relies heavily on the assumption that there are no point sources to subtract. Because EPA lacks the resources to complete point source subtraction on behalf of the states, it is possible that this may have led to double-counting of emissions.

4.23.3.1 *Notes about the Solvent Tool for 2014v1*

Retired SCCs Unretired for NJ

New Jersey noted late in the submission period that EPA had retired several SCC codes that were meaningful to their inventory. NJ asked that EPA un-retire these codes, with the rationale that the Ozone Transport Commission Stationary and Area Source Committee targets high VOC area source categories for regulation, based on California regulations. Therefore, EPA made the decision to un-retire these codes in a silent fashion. The categories include: Consumer Products, Autobody Refinishing, Pesticide Application, Graphic Arts, and Asphalt Paving. EPA then needed to go back and review the nonpoint survey to make sure that any double-counting didn't occur at this point.

Two Versions/Graphic Arts

It should also be noted that two Versions of the Solvent Tool were released for states to use in the 2014v1 NEI. In the history of the ERTAC committee, two different methodologies have been used for the estimation of Graphic Arts emissions. One is based on employment, using a lb VOC/employee unit, and the other is based on population, using a lb VOC/capita unit. States differed on their preference, so it was decided by the NOMAD Committee to release two versions of the tool, identical in nature except for the graphic arts emission factor and activity. While EPA gave states the allowance to choose which methodology to use, EPA made the final decision to use the employment methodology for EPA estimates.

This did cause issues for Graphic Arts for the 2014v1 NEI. Publishing two tools created disparities; population-based often resulted in emissions a factor of ten or greater than the employment basis. Several states revised their emissions accordingly.

Incorrect HAPs for Tool

Another disparity that had to be addressed in 2014v1 was that the HAPs that were published in the Solvent Tool on SharePoint in time for S/L/Ts to utilize in 2014v1 were ones that were EPA had derived from some EPA/SPPD data in the 2011v2 NEI. These HAPs emission factors had never been reviewed by S/L/Ts, as they were only input into the 2011v2 NEI (due to timing of the development of the HAPs). In retrospect, these HAPs were very different from previous inventories (completely different pollutant sets) and were not extrapolated in a technically-defensible manner. Therefore, because the published tool used faulty HAP emission factors, EPA had to tag out S/L/T-submitted solvent HAPs. These HAPs were then created from S/L/T-submitted VOC emissions via the HAP augmentation file, which used speciation factors from VOC to create VOC HAPs. New HAPs were developed to have more correct HAPs included in the 2014v1 NEI.

The VOC HAP factors are weight fractions of chemical species comprising total reactive VOCs. The speciation factor, or weight fraction, for each HAP is multiplied by the nonpoint VOC emissions (i.e. after point source subtraction). The speciation factors have historically been based on data from the Freedonia Group [ref **Error! Reference source not found.**] which provides information on the amount of solvent demand by solvent type (e.g. toluene, xylene, etc.). The speciation factors are developed by dividing the demand for each solvent type by the total solvent usage. Previous editions of the Freedonia data broke this information down by type of solvent and industry; however, the most recent version of the Freedonia data breaks it down by either type of solvent or industry, but not both. For this reason, if a newly calculated speciation factor using 2013 Freedonia data is significantly larger (i.e. by an order of magnitude) than the factor used in the 2011 NEI, then the factor is not changed and the 2011 factor is carried forward.

The tool was revised for the 2014v2 NEI; however, no changed to HAPs are noted because we used the correct factors in 2014v1 by using HAP Augmentation factors in EIS, rather than the Solvent tool to compute HAPs in 2014v1.

State Tagged Data

A few states (NH, TX, and VA) requested that we tag out their data after reviewing it in the draft. These were for: NH surface coating (electronic and other electrical, factory finished wood, and machinery and equipment), TX surface coating (special purpose coatings), and VA traffic markings and ag pesticides. As requested by inventory developers in these state air agencies, EPA estimates were used in lieu of the state submitted data.

EPA Tagged Data

Several S/L/Ts, listed in Table 4-147, answered on the nonpoint survey that they did not have specific solvent categories in their area of responsibility, or that these sources were completely covered in their point inventory submittal; therefore, EPA tagged out any emissions from the 2014 EPA Nonpoint Dataset to ensure that EPA emissions did not backfill where S/L/Ts did not submit nonpoint estimates.

Table 4-147: S/L/Ts that requested EPA not backfill nonpoint Solvent estimates with EPA estimates

S/L/T	Solvent category(s)	Reason to not include in NP Inventory
AK	Ag Pesticides, Surface Coating (auto, factory wood, industrial maintenance, motor vehicles, special purpose, wood furniture, architectural coatings)	Do not have this type of source
CA	Consumer & Commercial (adhesives/sealants, personal care products)	Use different SCCs
Chattanooga County	Dry cleaning, Consumer & Commercial (adhesives/sealants, automotive aftermarket, coatings, FIFRA, household, personal care, miscellaneous); Surface Coating (architectural coatings, auto refinishing, electronic, factory wood, industrial maintenance, marine, metal cans, metal furniture, other special purpose, paper, traffic markings, wood furniture)	No to Use EPA estimates
CO	Degreasing, Dry Cleaning, Graphic Arts, all Surface Coatings (except architectural coatings)	All covered in point source inv.

S/L/T	Solvent category(s)	Reason to not include in NP Inventory
CT	Dry Cleaning, Consumer & Commercial (adhesives/sealants, automotive aftermarket, coatings, FIFRA, household, personal care, miscellaneous), Surface Coating (architectural coatings, auto refinishing, factory wood, industrial maintenance, appliances, metal cans, metal furniture, other special purpose, railroad, traffic markings)	No to Use EPA estimates
NH	Graphic Arts	All covered in point inventory
DC	Degreasing, Dry Cleaning, Consumer & Commercial (automotive aftermarket, coatings, FIFRA, household personal care, misc. products, adhesives/sealants), Surface Coatings (architectural coatings, auto refinishing, industrial maintenance, misc. manuf., special purpose wood furniture, marine)	No to Use EPA estimates
DE	Surface Coating (motor vehicles, special purpose)	Do not have this type of source
IL	Dry Cleaning	No to use EPA estimates
IA	Consumer & Commercial (adhesive/sealant, automotive aftermarket, coatings, FIFRA, household, personal care, miscellaneous), Surface Coating (arch. Coatings)	No to use EPA estimates
KY	Degreasing, Dry Cleaning	All covered in point inventory
KY	Surface Coating (industrial maintenance, machinery, metal cans, special purpose)	Do not have this type of source
KY	Surface Coating (aircraft, electronic, appliances, marine, metal furniture, miscellaneous manufacturing, motor vehicles, paper, railroad)	No to use EPA estimates
Knox County	Consumer & Commercial (adhesives/sealants, auto aftermarket, coatings, FIFRA, household, personal care, misc. products, marine)	No to use EPA estimates
MS	Surface Coating (aircraft, auto refinishing, electronic, factory wood, industrial maintenance, appliances, machinery, marine, metal cans, metal furniture, miscellaneous manufacturing, motor vehicles, other special purpose, paper, traffic markings, wood furniture)	All covered in point inventory
NV	Surface Coating (marine)	Do not have this type of source
NH	Surface Coating (large appliances)	Do not have this type of source
NJ	Surface Coating (wood furniture)	Do not have this type of source
NJ	Consumer & Commercial (adhesives/sealants, auto aftermarket, coatings, FIFRA, household, personal care, misc. products), Surface Coating (auto refinishing)	No to use EPA estimates
OH	Surface Coating (architectural coatings)	No to use EPA estimates
OK	Consumer & Commercial (adhesives/sealants, auto aftermarket, coatings, FIFRA, household, personal care, misc. products), Surface Coatings (architectural coatings, auto refinishing, factory wood, industrial maintenance, metal cans, metal furniture, special purpose coatings, paper, traffic markings, wood furniture)	No to use EPA estimates
PR	Ag Pesticide, Surface Coating (metal cans, metal furniture, paper, railroad, architectural coatings)	Do not have this type of source

S/L/T	Solvent category(s)	Reason to not include in NP Inventory
RI	Dry Cleaning	All covered in point inventory
RI	Surface Coating (motor vehicles)	Do not have this type of source
SC	Surface Coating (auto refinishing, industrial maintenance, traffic markings)	No to use EPA estimates
Washoe County	Surface Coating (factory finished wood, industrial maintenance coatings, metal furniture, special purpose, railroad)	No to use EPA estimates
WI	Consumer & Commercial (adhesives/sealants, auto aftermarket, coatings, FIFRAZ, household, personal care, miscellaneous products), Surface Coating (architectural coatings)	No to use EPA estimates
WY	Surface Coating (metal can)	Do not have this type of source

4.23.3.2 *Known Issues in the 2014v1 NEI and 2017 NEI considerations*

The Solvent Tool developers realized that when they updated the HAP speciation factors, they used the incorrect codes for two of the HAP pollutants from traffic markings. They accidentally used the code for methyl isobutyl ketone when they should have used toluene, and further, they used the code for toluene when they should have used xylenes. This was corrected in the version of the tool, used and posted for, 2014v2 NEI. Another issue noted by Virginia concerns traffic marking and was corrected for in the 2014v2 NEI.

Suggested Improvements for the Solvents Tool for the 2017 NEI (from the NOMAD Committee)

- HAP point inventory subtraction, even if the S/L/T doesn't provide HAPs
- Standardize the sort of counties/SCCs between tools
- Look into whether additional columns added to the excel sheets will foul up the import feature (as Missouri noted)
- Add a warning screen that point source subtraction should be on an "uncontrolled" basis
- Provide a column in the Emission Factor which give the source of the factors
- Provide a column in the Emission Factor table to show the relationship between VOC and HAP
- Population of an emissions comment field, summarizing all mapped-point source SCCs
- Reporting period comment field to update if updating population

4.23.4 References for solvents: all other solvents

1. Freedonia Group, The. 2013 Solvents to 2018. Study 2357

4.24 Waste Disposal: Open Burning

There are three sections in this documentation that discuss nonpoint inventory Waste Disposal. This section discusses Open Burning; the next section discusses Publicly-Owned Treatment Works (POTWs), and the third section was a broad discussion of nonpoint non-combustion sources of mercury (see Section 4.2), which included several Waste Disposal sector sources. The reason these sources are broken up within this EIS sector is because the EPA methodologies for estimating the emissions are different.

4.24.1 Source category description

This sector includes several types of intentional burning for waste disposal purposes, except for agricultural purposes. This source category includes open burning of municipal solid waste, land clearing debris, and different types of yard waste.

4.24.2 Sources of data

Table 4-148 shows, for open burning, the nonpoint SCCs in the 2014 NEI as well as SCCs that the EPA estimates. The SCC level 3 and 4 SCC descriptions are also provided. The SCC level 1 and 2 descriptions are "Waste Disposal, Treatment, and Recovery; Open Burning" for all SCCs.

Table 4-148: Open Burning SCCs with 2014 NEI emissions

EPA Estimate?	SCC	Description
Y	2610000100	All Categories; Yard Waste - Leaf Species Unspecified
	2610000300	All Categories; Yard Waste - Weed Species Unspecified (including Grass)
Y	2610000400	All Categories; Yard Waste - Brush Species Unspecified
Y	2610000500	All Categories; Land Clearing Debris (use 28-10-005-000 for Logging Debris Burning)
Y	2610030000	Residential; Household Waste (use 26-10-000-xxx for Yard Wastes)

The agencies listed in Table 4-149 submitted VOC emissions for open burning; agencies not listed used EPA estimates for these sources.

Table 4-149: Percentage of Open Burning NO_X, $PM_{2.5}$ and VOC emissions submitted by reporting agency

Region	Agency	S/L/T	SCC	Description	NO_X	$PM_{2.5}$	VOC
1	Vermont Department of Environmental Conservation	State	2610030000	Residential; Household Waste	100		100
2	New Jersey Department of Environment Protection	State	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
2	New Jersey Department of Environment Protection	State	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
2	New Jersey Department of Environment Protection	State	2610030000	Residential; Household Waste	100	100	100
3	Delaware Department of Natural Resources and Environmental Control	State	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
3	Delaware Department of Natural Resources and Environmental Control	State	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
3	Delaware Department of Natural Resources and Environmental Control	State	2610000500	All Categories; Land Clearing Debris	100	100	100
3	Delaware Department of Natural Resources and Environmental Control	State	2610030000	Residential; Household Waste	100	100	100

Region	Agency	S/L/T	SCC	Description	NO_X	$PM_{2.5}$	VOC
3	Maryland Department of the Environment	State	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
3	Maryland Department of the Environment	State	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
3	Maryland Department of the Environment	State	2610000500	All Categories; Land Clearing Debris	100	100	100
3	Maryland Department of the Environment	State	2610030000	Residential; Household Waste	100	100	100
4	Georgia Department of Natural Resources	State	2610000500	All Categories; Land Clearing Debris	100	100	100
4	North Carolina Department of Environment and Natural Resources	State	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
4	North Carolina Department of Environment and Natural Resources	State	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
4	North Carolina Department of Environment and Natural Resources	State	2610000500	All Categories; Land Clearing Debris	100	100	100
4	North Carolina Department of Environment and Natural Resources	State	2610030000	Residential; Household Waste	100	100	100
5	Illinois Environmental Protection Agency	State	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
5	Illinois Environmental Protection Agency	State	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
5	Illinois Environmental Protection Agency	State	2610000500	All Categories; Land Clearing Debris	100	100	100
5	Illinois Environmental Protection Agency	State	2610030000	Residential; Household Waste	100	100	100
5	Minnesota Pollution Control Agency	State	2610030000	Residential; Household Waste	65		91
6	Texas Commission on Environmental Quality	State	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
6	Texas Commission on Environmental Quality	State	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
6	Texas Commission on Environmental Quality	State	2610030000	Residential; Household Waste	100	100	100
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)			100
7	Sac and Fox Nation of Missouri in Kansas and Nebraska Reservation	Tribe	2610030000	Residential; Household Waste	100	100	100

Region	Agency	S/L/T	SCC	Description	NO_X	$PM_{2.5}$	VOC
8	Northern Cheyenne Tribe	Tribe	2610000100	All Categories; Yard Waste - Leaf Species Unspecified		100	100
8	Northern Cheyenne Tribe	Tribe	2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)		100	100
8	Northern Cheyenne Tribe	Tribe	2610000400	All Categories; Yard Waste - Brush Species Unspecified		100	100
8	Northern Cheyenne Tribe	Tribe	2610030000	Residential; Household Waste	100	100	100
8	Utah Division of Air Quality	State	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
8	Utah Division of Air Quality	State	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
8	Utah Division of Air Quality	State	2610030000	Residential; Household Waste	100	100	100
9	California Air Resources Board	State	2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)	100	100	100
9	Maricopa County Air Quality Department	Local	2610000500	All Categories; Land Clearing Debris	100	100	100
9	Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California	Tribe	2610030000	Residential; Household Waste	100	100	100
9	Washoe County Health District	Local	2610030000	Residential; Household Waste	100	100	100
10	Coeur d'Alene Tribe	Tribe	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
10	Coeur d'Alene Tribe	Tribe	2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)	100	100	100
10	Coeur d'Alene Tribe	Tribe	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
10	Coeur d'Alene Tribe	Tribe	2610030000	Residential; Household Waste	100	100	100
10	Idaho Department of Environmental Quality	State	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
10	Idaho Department of Environmental Quality	State	2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)	100	100	100

Region	Agency	S/L/T	SCC	Description	NO_X	$PM_{2.5}$	VOC
10	Idaho Department of Environmental Quality	State	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
10	Idaho Department of Environmental Quality	State	2610030000	Residential; Household Waste	100	100	100
10	Kootenai Tribe of Idaho	Tribe	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
10	Kootenai Tribe of Idaho	Tribe	2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)	100	100	100
10	Kootenai Tribe of Idaho	Tribe	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
10	Kootenai Tribe of Idaho	Tribe	2610030000	Residential; Household Waste	100	100	100
10	Nez Perce Tribe	Tribe	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
10	Nez Perce Tribe	Tribe	2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)	100	100	100
10	Nez Perce Tribe	Tribe	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
10	Nez Perce Tribe	Tribe	2610030000	Residential; Household Waste	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	2610030000	Residential; Household Waste	100	100	100
10	Washington State Department of Ecology	State	2610000100	All Categories; Yard Waste - Leaf Species Unspecified	100	100	100
10	Washington State Department of Ecology	State	2610000300	All Categories; Yard Waste - Weed Species Unspecified (incl Grass)	100	100	100
10	Washington State Department of Ecology	State	2610000400	All Categories; Yard Waste - Brush Species Unspecified	100	100	100
10	Washington State Department of Ecology	State	2610030000	Residential; Household Waste	100	100	100

4.24.3 EPA-developed emissions for open burning: updated for 2014v2 NEI

4.24.3.1 *Land Clearing Debris*

Open burning of land clearing debris is the purposeful burning of debris, such as trees, shrubs, and brush, from the clearing of land for the construction of new buildings and highways. Criteria air pollutant (CAP) and hazardous air pollutant (HAP) emission estimates from open burning of land clearing debris are a function of the amount of material or fuel subject to burning per year.

The amount of material burned was estimated using the county-level total number of acres disturbed by residential, non-residential, and road construction. County-level weighted loading factors were applied to the total number of construction acres to convert acres to tons of available fuel.

<u>Acres Disturbed from Residential Construction</u>

The US Census Bureau has 2014 data for *Housing Starts - New Privately Owned Housing Units Started* [ref 1, ref2], which provides regional level housing starts based on the groupings of 1 unit, 2-4 units, 5 or more units. A consultation with the Census Bureau in 2002 gave a breakdown of approximately 1/3 of the housing starts being for 2-unit structures, and 2/3 being for 3 and 4-unit structures. The 2-4-unit category was divided into 2-units, and 3-4 units based on this ratio. To determine the number of structures for each grouping, the 1-unit category was divided by 1, the 2-unit category was divided by 2, and the 3-4-unit category was divided by 3.5. The 5 or more unit category may be made up of more than one structure. *New Privately Owned Housing Units Authorized Unadjusted Units* [ref 3] gives a conversion factor to determine the ratio of structures to units in the 5 or more unit category. For example, if a county has one 40-unit apartment building, the ratio would be 40/1. If there are 5 different 8-unit buildings in the same project, the ratio would be 40/5. Structures started by category are then calculated at a regional level. The table *Annual Housing Units Authorized by Building Permit* [ref 4] has 2014 data at the county level to allocate regional housing starts to the county level. This results in county level housing starts by number of units. Table 4-150 shows the surface areas assumed disturbed for each unit type.

Table 4-150: Surface Acres Disturbed per Unit Type

Unit Type	Surface Acres Disturbed
1-Unit	1/4 acre/structure
2-Unit	1/3 acre/structure
Apartment	1/2 acre/structure

The 3-4 unit and 5 or more unit categories were considered to be apartments. Multiplication of housing starts to surface acres disturbed results in total number of acres disturbed for each unit category.

<u>Acres Disturbed from Non-Residential Construction</u>

Annual Value of Construction Put in Place in the U.S [ref 5] has the 2014 National Value of Non-residential construction. The national value of non-residential construction put in place (in millions of dollars) was allocated to counties using county-level non-residential construction (NAICS Code 2362) employment data obtained from *County Business Patterns* (*CBP)*. [ref 6]. Because some county employment data are withheld due to privacy concerns, the following procedure was adopted:

1. State totals for the known county level employees were subtracted from the number of employees reported in the state level version of CBP. This results in the total number of withheld employees in the state.
2. A starting estimate of the midpoint of the range code was used (so for instance in the 1-19 employees range, an estimate of 10 employees would be used) and a state total of the withheld counties was computed.
3. A ratio of estimated employees (Step 2) to withheld employees (Step 1) was then used to adjust the county level estimates up or down so the state total of adjusted guesses should match state total of withheld employees (Step 1).

In 1999 a figure of 2 acres/$\$10^6$ was developed. The Bureau of Labor Statistics *Producer Price Index* [ref 7] lists costs of the construction industry from 1999-2014.

2014 acres per $\$10^6$ = 1999 acres per $\$10^6$ x (1999 PPI / 2014 PPI)

= 2 acres/$\$10^6$ (132.9 / 232.1)

= 1.145 acres per $\$10^6$

Acres Disturbed by Road Construction

The Federal Highway Administration provides data on spending by state in several different categories of road construction and maintenance in *Highway Statistics, Section IV - Highway Finance, Table SF-12A, State Highway Agency Capital Outlay* [ref **Error! Reference source not found.**] for year 2014. For this SCC, the following sets of d ata (or columns) are used: New Construction, Relocation, Added Capacity, Major Widening, and Minor Widening. Each of these data sets is also differentiated according to the following six roadway classifications:

1. Interstate, urban
2. Interstate, rural
3. Other arterial, urban
4. Other arterial, rural
5. Collectors, urban
6. Collectors, rural

The State expenditure data are then converted to new miles of road constructed using $/mile conversions obtained from the Florida Department of Transportation (FLDOT) in 2014 [ref **Error! Reference source not f ound.**]. A conversion of $6.8 million/mile is applied to the urban interstate expenditures and a conversion of $3.8 million/mile is applied to the rural interstate expenditures. For expenditures on other urban arterial and collectors, a conversion factor of $4.1 million/mile is applied, which corresponds to all other projects. For expenditures on other rural arterial and collectors, a conversion factor of $2.1 million/mile is applied, which corresponds to all other projects.

The new miles of road constructed are used to estimate the acreage disturbed due to road construction. The total area disturbed in each state is calculated by converting the new miles of road constructed to acres using an acres disturbed/mile conversion factor for each road type as given in Table 4-151.

Table 4-151: Spending per Mile and Acres Disturbed per Mile by Highway Type

Road Type	Thousand Dollars per mile	Total Affected Roadway Width (ft)*	Acres Disturbed per mile
Urban Areas, Interstate	6,895	94	11.4
Rural Areas, Interstate	3,810	89	10.8
Urban Areas, Other Arterials	4,112	63	7.6
Rural Areas, Other Arterials	2,076	55	6.6
Urban Areas, Collectors	4,112	63	7.6
Rural Areas, Collectors	2,076	55	6.6
**Total Affected Roadway Width = (lane width (12 ft) * number of lanes) + (shoulder width * number of shoulders) + area affected beyond road width (25 ft)*			

County-level building permits data are used to allocate the state-level acres disturbed by road construction to the county [ref 10]. A ratio of the number of building starts in each county to the total number of building starts in each state was applied to the state-level acres disturbed to estimate the total number of acres disturbed by road construction in each county.

<u>Converting Acres Disturbed to Tons of Land Clearing Debris Burned</u>

Version 2 of the Biogenic Emissions Landuse Database (BELD2) within EPA's Biogenic Emission Inventory System (BEIS) [ref 11] was used to identify the acres of hardwoods, softwoods, and grasses in each county. Table 4-152 presents the average fuel loading factors by vegetation type. The average loading factors for slash hardwood and slash softwood were adjusted by a factor of 1.5 to account for the mass of tree that is below the soil surface that would be subject to burning once the land is cleared [ref 12]. Weighted average county-level loading factors were calculated by multiplying the average loading factors by the percent contribution of each type of vegetation class to the total land area for each county.

Table 4-152: Fuel Loading Factors (tons/acres) by Vegetation Type

Vegetation Type	Unadjusted Average Fuel Loading Factor	Adjusted Average Fuel Loading Factor
Hardwood	66	99
Softwood	38	57
Grass	4.5	Not Applicable

The total acres disturbed by all construction types was calculated by summing the acres disturbed from residential, non-residential, and road construction. The county-level total acres disturbed were then multiplied by the weighted average loading factor to derive tons of land clearing debris.

Because BELD2 does not contain data on Alaska and Hawaii, the acres of hardwoods, softwoods, and grasses in each county was estimated by using the state-level land cover statistics from the USGS National Land Cover Database on the percent land cover under each vegetation type [ref 13]. These percentages were multiplied by the county area (acres), from the U.S. Census Bureau [ref 14].

Controls for land clearing debris burning are generally in the form of a ban on open burning of waste in each municipality or county. Counties that were more than 80% urban, by land area, determined by the 2010 U.S. Census data [ref 14], were assumed not to practice any open burning. Therefore, criteria pollutant and HAP emissions from open burning of land clearing debris are zero in these counties. In addition, the State of Colorado implemented a state-wide ban on open burning. Emissions from open burning of land clearing debris in all Colorado counties were assumed to be zero.

Activity data and emissions for Clark County, NV, were zeroed out based on data from the Clark County Department of Air Quality that indicates that there is very little vegetation to be cleared in that county and that there is an effective burn ban in place.

Emission factors for CAPs were developed by EPA in consultation with ERTAC, and are based primarily on the AP-42 report [ref 15, ref 16]. The PM2.5 to PM10 emission factor ratio for brush burning (0.7709) was multiplied by the PM10 emission factors for land clearing debris burning to develop PM2.5 emission factors. Emission factors for HAPs are from an EPA Control Technology Center report [ref 17].

There were several significant changes from the 2011 inventory. This included the utilization of a newer information source to determine the spending per mile and acres disturbed per mile for each roadway type. The previous inventory calculations were based on information from the NC DOT from 2000, while this inventory instead uses data obtained from the FL DOT in 2014.

Additionally, the 80% urban no-burn threshold was based on the ratio of urban to rural population in the 2011 NEI methodology. These ratios were replaced with ratios based on urban and rural land area. In both cases, the data are from the 2010 census.

For the 2014v2 NEI, we updated the following activity data over what was used, or missing, in the 2014v1 NEI:

- Added SO2 emissions using an emissions factor from burning brush in yard waste
- Updated Federal Highway Administration spending data from year 2013 to year 2014
- Updated County and State Business Patterns data from year 2013 to year 2014
- Updated Puerto Rico and Virgin Islands Populations to year 2014
- Removed emissions for locality as dictated by new data presented to EPA

4.24.3.2 *Residential Household Waste*

Open burning of residential municipal solid waste (MSW) is the purposeful burning of MSW in outdoor areas. Criteria air pollutant (CAP) and hazardous air pollutant (HAP) emission estimates for MSW burning are a function of the amount of waste burned per year.

The amount of household MSW burned was estimated using data from EPA's report *Advancing Sustainable Materials Management: 2013 Fact Sheet* [ref 18,ref 19]. The report presents the total mass of waste generated from the residential and commercial sectors in the United States by type of waste for the calendar year 2013. According to the 2010 version of the EPA report, residential waste generation accounts for 55-65 percent of the total waste from the residential and commercial sectors [ref 20]. For the calculation of per capita household waste subject to burning, the median value of 60 percent was assumed. This information was used to calculate a daily estimate of combustible per capita household waste of 1.91 lbs/person/day, and a daily estimate of combustible plus non-combustible per capita household waste of 2.62 lbs/person/day. Burning of yard waste is included in SCC 2610000100 and SCC 2610000400; therefore, it is not part of residential MSW. Approximately 24 percent of the rural population that may open burn does so [ref 21].

Since open burning is generally not practiced in urban areas, only the rural and like rural population in each county was assumed to practice open burning. Like rural population is defined as the population of urbanized areas and urban clusters with population densities' equal to or less than the maximum rural population density value for all counties. The ratio of rural and like rural to total population was obtained from 2010 U.S. Census data [ref 14]. This ratio was then multiplied by the 2014 U.S. Census Bureau estimate [ref 22] of the population in each county to obtain the county-level rural population for 2014. The county-level rural population was then multiplied by the per capita household waste subject to burning to determine the amount of rural household MSW generated in each county in 2014.

Controls for residential MSW burning are generally in the form of a ban on open burning of waste in each municipality or county. However, literature suggests that burn bans are not 100% effective. It was therefore assumed that approximately 25% of the residents that may burn trash in the yard would burn waste even if a ban is in place [ref 21]. For counties that have burn bans, the assumption was applied by multiplying 0.25 by the number of persons estimated to practice open burning. For example, the State of Colorado implemented a state-wide ban on open burning, and this method was employed for all counties in Colorado.

Emission factors for CAPs were developed by the U.S. Environmental Protection Agency (EPA) in consultation with the Eastern Regional Technical Advisory Committee and based primarily on the AP-42 report [ref 15, ref 16, ref 23]. Emission factors for HAPs are from an EPA Control Technology Center report and an EPA Office of Research and Development report [ref 23, ref 17]. Emissions from dioxin congeners are also available, but these are excluded from the NEI due to their uncertainty.

For the 2014v2 NEI, we updated the following assumptions over what was used in the 2014v1 NEI:

- The computation of “like rural” population in each county
- We now assume that counties with burn bans will still have 25% of people likely to still burn despite the bans

4.24.3.3 *Yard Waste- Leaf and Brush Debris*

Open burning of yard waste is the purposeful burning of leaf and brush species in outdoor areas. Criteria air pollutant (CAP) and hazardous air pollutant (HAP) emission estimates for leaf and brush waste burning are a function of the amount of waste burned per year.

The amount of household MSW burned was estimated using data from EPA’s Advancing Sustainable Materials Management: 2013 Fact Sheet [ref 18, ref 19]. The report presents the total mass of waste generated from the residential and commercial sectors in the United States by type of waste for the calendar year 2013. According to the 2010 version of the EPA report, residential waste generation accounts for 55-65 percent of the total waste from the residential and commercial sectors [ref 20]. For the calculation of per capita yard waste subject to burning, the median value of 60 percent was assumed. This information was used to calculate a daily estimate of the per capita yard waste of 0.36 lbs/person/day. Of the total amount of yard waste generated, the yard waste composition was assumed to be 25 percent leaves, 25 percent brush, and 50 percent grass by weight [ref 24].

Open burning of grass clippings is not typically practiced by homeowners, and therefore, only estimates for leaf burning and brush burning were developed. Approximately 25 to 32 percent of all waste that is subject to open burning is actually burned [ref 24]. A median value of 28 percent is assumed to be burned in all counties in the United States.

The per capita estimate was then multiplied by the 2014 population in each county that is expected to burn waste. Since open burning is generally not practiced in urban areas, only the rural population and “like rural” population in each county was assumed to practice open burning. Like rural population is defined as the population of urbanized areas and urban clusters with population densities equal to or less than the maximum rural population density value for all counties. The ratio of rural and like rural to total population was obtained from 2010 U.S. Census data [ref 14]. This ratio was then multiplied by the 2014 U.S. Census Bureau estimate [ref 22] of the population in each county to obtain the county-level rural population for 2014.

The percentage of forested acres from Version 2 of BELD2 within BEIS was used to adjust for variations in vegetation [ref 11]. The percentage of forested acres per county (including rural forest and urban forest) was then determined. To better account for the native vegetation that would likely be occurring in the residential yards of farming States, agricultural land acreage was subtracted before calculating the percentage of forested acres. Table 4-153 presents the ranges that were used to adjust the amount of yard waste that is assumed to be generated per county. All municipios in Puerto Rico and counties in the U.S. Virgin Islands, Hawaii, and Alaska were assumed to have greater than 50 percent forested acres.

Table 4-153: Adjustment for Percentage of Forested Acres

Percent Forested Acres per County	Adjustment for Yard Waste Generated
< 10%	0% generated
>= 10% to < 50%	50% generated
>=50%	100% generated

Controls for residential MSW burning are generally in the form of a ban on open burning of waste in a given municipality or county. However, literature suggests that burn bans are not 100% effective. It was therefore assumed that approximately 25% of the residents that may burn trash in the yard would burn waste even if a ban is in place. For counties that have burn bans, the assumption was applied by multiplying .25 by the number of persons estimated to practice open burning. For example, the State of Colorado implemented a state-wide ban on open burning, and this method was employed for all counties in Colorado.

Counties that were more than 80% urban, by land area, determined by the 2010 U.S. Census data. were assumed not to practice any open burning. Therefore, criteria pollutant and HAP emissions from residential yard waste burning are zero in these counties. In addition, the State of Colorado implemented a state-wide ban on open burning. Emissions from open burning of residential yard waste in all Colorado counties were assumed to be zero.

Emission factors for CAPs were developed by the EPA in consultation with the Eastern Regional Technical Advisory Committee [ref 15]. For leaf burning, emission factors for $PM_{2.5}$ were calculated by multiplying the PM_{10} leaf burning emission factors by the $PM_{2.5}$ to PM_{10} emission factor ratio for brush burning (0.7709). Emission factors for HAPs are from an EPA Control Technology Center report. Emissions from dioxin congeners are also available, but these are excluded from the NEI due to their uncertainty.

For the 2014v2 NEI, we updated the following assumptions over what was used in the 2014v1 NEI:

- The computation of "like rural" population in each county
- We now assume that counties with burn bans will still have 25% of people likely to still burn despite the bans

4.24.4 References for open burning

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4.25 Waste Disposal: Nonpoint POTWs

4.25.1 Source category description

This sector, Publicly Owned Treatment Works (POTW), includes treatment works owned by a state, municipality, city, town, special sewer district, or other publicly owned and financed entity, as opposed to a privately (industrial) owned treatment facility. The definition includes intercepting sewers, outfall sewers, sewage collection systems, pumping, power, and other equipment. The wastewater treated by these POTWs is generated by industrial, commercial, and domestic sources. The SCC that EPA uses for estimated nonpoint emissions is 2630020000; the SCC description is "Waste Disposal, Treatment, and Recovery; Wastewater Treatment; Public Owned; Total Processed".

4.25.2 Sources of data

The agencies listed in Table 4-154 submitted VOC emissions for POTWs; agencies not listed used EPA estimates.

Table 4-154: Percentage of nonpoint POTW VOC and $PM_{2.5}$ emissions submitted by reporting agency

Region	Agency	S/L/T	VOC	$PM_{2.5}$
1	Maine Department of Environmental Protection	State	100	
1	Vermont Department of Environmental Conservation	State	100	
2	New York State Department of Environmental Conservation	State	100	
3	Maryland Department of the Environment	State	100	
4	Knox County Department of Air Quality Management	Local	100	
4	Metro Public Health of Nashville/Davidson County	Local	100	
5	Illinois Environmental Protection Agency	State	100	
5	Michigan Department of Environmental Quality	State	100	
5	Ohio Environmental Protection Agency	State	100	
6	Texas Commission on Environmental Quality	State	100	
8	Utah Division of Air Quality	State	100	
9	Clark County Department of Air Quality and Environmental Management	Local		100
9	Washoe County Health District	Local	100	
10	Coeur d'Alene Tribe	Tribe	100	
10	Idaho Department of Environmental Quality	State	100	
10	Kootenai Tribe of Idaho	Tribe	100	
10	Nez Perce Tribe	Tribe	100	
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100	
10	Washington State Department of Ecology	State	100	

4.25.3 EPA-developed emissions for nonpoint POTWs: no changes for 2014v2 NEI

The general approach to calculating 2014 emissions for POTWs is to multiply the 2012 flow rate by the emission factors for VOCs, ammonia, and 53 HAPs. The emissions are allocated to the county level using methods described below. More details including references to the documentation can be found in the document "*2014_POTW_nonpoint_emissions_23mar2016.zip*" on the 2014v1 Supplemental Data FTP site.

4.25.3.1 *Activity data*

The EPA Clean Watersheds Needs Survey reports the existing flow rate in 2012 for POTWs as 28,296 million gallons per day (MMGD). The nationwide flow rate includes Puerto Rico and the U.S. Virgin Islands. Flow rates were allocated to each county by the county proportion of the U.S. population.

It should be noted that the derivation of the nationwide flow rate for the 2014 nonpoint POTW emissions inventory differs from the derivation of the nationwide flow rate used to estimate year 2011 nonpoint POTW emissions. The methodology for the 2011 nonpoint POTW emissions inventory used a projected 2010 nationwide flow rate of 39,780 MMGD that was available from an EPA report. The projection was based on

Needs Surveys from 1984 to 1996. The 2012 nationwide flow rate used for the 2014 inventory is not a projection, but a value directly reported by the 2012 Needs Survey.

4.25.3.2 *Emission Factors*

The ammonia emission factor was obtained from a report to EPA, while the VOC emission factor was based on a TriTAC study. Emission factors for the 52 HAPs were derived using 1996 area source emissions estimates that were provided by ESD and the 1996 nationwide flow rate. These HAP emission factors were then multiplied by the 2008 to 2002 VOC emission factor ratio (0.85/9.9) to obtain the final HAP emission factors applied in the 2014 inventory.

4.25.3.3 *Emissions calculation*

Emissions per county for a given pollutant were computed by multiplying the pollutant emission factor (lb/million gallon) by the county flow rate (million gallons). This process was repeated for all counties in the U.S., Puerto Rico, and the U.S. Virgin Islands, and the result was pollutant specific nonpoint POTW county-level emissions.

The next step was to determine whether there are POTW point source emissions and to subtract those point source emissions from the total nonpoint emissions. The EIS was queried for POTW point sources, and the resulting output contained facility-level HAP and CAP emissions in fifteen states. The fifteen states were: CA, CO, FL, IA, IL, MA, MD, MI, MN, NC, NJ, NY, PA, TN, and TX. The facility-level point source emissions were summed to county and pollutant, and then were subtracted from the nonpoint POTW emissions by county and pollutant. For counties where the point source emissions were larger than the corresponding nonpoint emissions, the nonpoint emissions were set to zero.

4.26 Waste Disposal: Human Cremation

4.26.1 Source category description

This sector includes non-mercury emissions from human cremation; the mercury component of human cremation utilizes a slightly different methodology described in Section 4.2.6.. The SCC for human cremation is 2810060100; the SCC description is “Miscellaneous Area Sources: Other Combustion: Cremation: Humans”.

4.26.2 Sources of data

The agencies listed in Table 4-155 submitted at least NOX nonpoint emissions for human cremation; agencies not listed used EPA estimates. Values under 100 indicate that EPA estimates were used for some counties.

Table 4-155: Percentage of nonpoint human cremation NO_X emissions submitted by reporting agency

Region	Agency	S/L/T	NO_X
1	Maine Department of Environmental Protection	State	100
2	New York State Department of Environmental Conservation	State	100
3	Maryland Department of the Environment	State	69
3	Virginia Department of Environmental Quality	State	100
4	Knox County Department of Air Quality Management	Local	100
5	Ohio Environmental Protection Agency	State	100
7	Missouri Department of Natural Resources	State	25

Region	Agency	S/L/T	NO_X
9	Maricopa County Air Quality Department	Local	100
9	Washoe County Health District	Local	100
10	Coeur d' Alene Tribe	Tribe	100
10	Idaho Department of Environmental Quality	State	100
10	Nez Perce Tribe	Tribe	100
10	Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	Tribe	100

4.26.3 EPA-developed emissions for human cremation: new for 2014v2 NEI

EPA estimates were accidentally not included in the 2014v1 NEI; however, nationally, EPA only estimated 1,249 tons of NOX in 2014. For the 2014v2 NEI, we started with the 2011v2 NEI methodology and updated the following to create year 2014 estimates:

- population data to year 2014 using data from the U.S. Census [ref 1]
- number of state-level deaths to year 2014 [ref 2]
- percentage of bodies cremated in the U.S. updated to year 2014 [ref 3]
- emissions factor for chromium III and chromium VI from the EPA SPECIATE database [ref 4] and update to Cadmium emission factor

The 2014 EPA changes to the 2011 activity data are summarized in the spreadsheet “2014 modifications” in the workbook “human_cremation_281006011_emissions_modified_for_2014v2.xlsx” in the file “2014v2_Human_cremation_EPA.zip” on the 2014v2 Supplemental Data FTP site. More details on the activity data, emission factors and calculations are included in the workbook.

4.26.4 References for human cremation

1. U.S. Census Bureau, Population Division. Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2016, Year 2014 data, accessed March 2017.
2. Kochanek KD, Sherry, MA, Xu J, Murphy SL, Tejada-Vera, B, "Number of deaths, death rates, and age-adjusted death rates for major causes of death: United States, each state, Puerto Rico, Virgin Islands, Guam, American Samoa, and Northern Marianas, 2014" Table 19. Deaths, death rates, and age-adjusted death rates: United States, and each state and territory, final 2014, National Vital Statistics Reports, vol 65 no 4, p.21, Hyattsville, MD: National Center for Health Statistics, June 30, 2016.
3. Cremation Association of North America, Industry Statistical Information, Annual Statistics Report, accessed March 2017.
4. U.S. Environmental Protection Agency. 2016. SPECIATE Database v4.5.

5 Nonroad Equipment – Diesel, Gasoline and Other

Although "nonroad" is used to refer to all transportation sources that are not on-highway, this section addresses nonroad equipment other than locomotives, aircraft, or commercial marine vessels. Locomotive emissions from railyards and aircraft and associated ground support equipment are described in Section 3. Section 4 includes descriptions of the nonpoint portion of locomotives and the commercial marine vessel emissions.

5.1 Sector Description

This section deals specifically with emissions processes calculated by the EPA's NONROAD2008 model [ref 1] and the family of off-road models used by California [ref 2]. They include nonroad engines and equipment, such as lawn and garden equipment, construction equipment, engines used in recreational activities, portable industrial, commercial, and agricultural engines. Nonroad equipment emissions are included in every state, the District of Columbia, Puerto Rico, and the Virgin Islands.

Nonroad mobile source emissions are generated by a diverse collection of equipment from lawn mowers to locomotive support. NONROAD estimates emissions from nonroad mobile sources using a variety of fuel types as shown in Table 5-1.

Table 5-1: MOVES-NONROAD equipment and fuel types

Equipment Types	Fuel Types
Recreational Construction Industrial Lawn and Garden Agriculture Commercial Logging Airport Ground Support Equipment (GSE) (excludes aircraft)* Underground Mining Oilfield** Pleasure Craft (recreational marine) (excludes commercial marine vessels) Railroad (excludes locomotives)	Compressed Natural Gas (CNG) Diesel Gasoline Liquified Petroleum Gas (LPG)

*Although NONROAD2008 estimates GSE, the results are not used in the NEI. NEI GSE estimates are instead calculated via the Federal Aviation Administration's Emission and Dispersion Modeling System (EDMS).

**Although NONROAD2008 estimates oil field equipment, the results are not used in the NEI, because they are duplicative of results from EPA's Oil and Gas Tool used in nonpoint source calculations.

5.2 MOVES-NONROAD

NONROAD2008, the latest public release of EPA's NONROAD Model, estimates daily emissions for total hydrocarbons (THC), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO_2), particulate matter 10 microns and less (PM_{10}), and sulfur dioxide (SO_2), as well as calculating fuel consumption. MOVES2014a (version 20151201) [ref 3] uses ratios from some of these emissions to calculate emissions for particulate matter 2.5

microns and less ($PM_{2.5}$), methane, ammonia (NH_3), 4 more aggregate hydrocarbon groups (NMHC, NMOG, TOG, and VOC), 14 hazardous air pollutants (HAPs), 17 dioxin/furan congeners, 32 polycyclic aromatic hydrocarbons, and 6 metals. For a complete list of these pollutants, see Table 5-2. All of the input and activity data required to run MOVES-NONROAD are contained within the Motor Vehicle Emissions Simulator (MOVES) default database, which is distributed with the model. State- and county-specific data can be used by creating a supplemental database known as a county database (CDB) and specifying it in the MOVES run specification (runspec). State, local and tribal (S/L/T) agencies can update the data within the CDBs to produce emissions estimates that accurately reflect local conditions and equipment usage. MOVES first uses the data in the CDBs and fills in any missing data from the MOVES default database.

MOVES-NONROAD is the new way of running NONROAD2008. Nonroad emissions for previous NEIs have been produced by running NONROAD2008 for all U.S. counties using the National Mobile Inventory Model (NMIM) [ref 4]. Now superseded by MOVES, NMIM was the EPA's consolidated mobile emissions estimation system that allowed the EPA to produce nonroad mobile emissions in a consistent and automated way for the entire country. NMIM was basically a user interface for NONROAD2008. It took data from the NMIM County Database (NCD) and used it to write input files for NONROAD2008 (called "opt" files), executed NONROAD2008, picked up the output, and put it into a MySQL database. It also generated additional pollutant estimates as ratios to those produced by NONROAD. As part of the EPA's continuing efforts to upgrade the NONROAD model, it was moved from NMIM into MOVES2014. Although MOVES is primarily a user interface for NONROAD, just as NMIM was, data are now stored in standard MySQL tables, the same as for the onroad sources, which are much easier to access and update than the original NONROAD ASCII files. The transfer to MOVES was tested by verifying that the NONROAD model and MOVES2014 produced identical results for the species produced by stand-alone NONROAD (THC, CO, CO_2, NOx, SO_2, PM_{10}, and fuel consumption). MOVES-NONROAD also includes improved estimation of HAPs, which are creating by post-processing NONROAD2008 output. MOVES2014-NONROAD produced THC, NOx, PM_{10}, $PM_{2.5}$, CO, SO_2, NH_3, CO_2, and fuel consumption. MOVES2014a added the ability to calculate all of the species mentioned above and listed in Table 5-2. At the same time, it based these calculations on much newer and better data than had been used in NMIM [refs 5,6].

Table 5-2: Pollutants produced by MOVES-NONROAD for 2014 NEI

Pollutant ID	Pollutant Name	Pollutant ID	Pollutant Name
1	Total Gaseous Hydrocarbons	83	Phenanthrene particle
2	Carbon Monoxide (CO)	84	Pyrene particle
3	Oxides of Nitrogen (NOx)	86	Total Organic Gases
5	Methane (CH_4)	87	Volatile Organic Compounds
20	Benzene	88	NonHAPTOG
21	Ethanol	90	Atmospheric CO_2
22	MTBE	99	Brake Specific Fuel Consumption (BSFC)
23	Naphthalene particle	100	Primary Exhaust PM_{10} - Total
24	1,3-Butadiene	110	Primary Exhaust $PM_{2.5}$ - Total
25	Formaldehyde	130	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin
26	Acetaldehyde	131	Octachlorodibenzo-p-dioxin
27	Acrolein	132	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin
30	Ammonia (NH_3)	133	Octachlorodibenzofuran
31	Sulfur Dioxide (SO_2)	134	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin
40	2,2,4-Trimethylpentane	135	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin
41	Ethyl Benzene	136	2,3,7,8-Tetrachlorodibenzofuran

Pollutant ID	Pollutant Name	Pollutant ID	Pollutant Name
42	Hexane	137	1,2,3,4,7,8,9-Heptachlorodibenzofuran
43	Propionaldehyde	138	2,3,4,7,8-Pentachlorodibenzofuran
44	Styrene	139	1,2,3,7,8-Pentachlorodibenzofuran
45	Toluene	140	1,2,3,6,7,8-Hexachlorodibenzofuran
46	Xylene	141	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin
60	Mercury Elemental Gaseous	142	2,3,7,8-Tetrachlorodibenzo-p-Dioxin
61	Mercury Divalent Gaseous	143	2,3,4,6,7,8-Hexachlorodibenzofuran
62	Mercury Particulate	144	1,2,3,4,6,7,8-Heptachlorodibenzofuran
63	Arsenic Compounds	145	1,2,3,4,7,8-Hexachlorodibenzofuran
65	Chromium 6+	146	1,2,3,7,8,9-Hexachlorodibenzofuran
66	Manganese Compounds	168	Dibenzo(a,h)anthracene gas
67	Nickel Compounds	169	Fluoranthene gas
68	Dibenzo(a,h)anthracene particle	170	Acenaphthene gas
69	Fluoranthene particle	171	Acenaphthylene gas
70	Acenaphthene particle	172	Anthracene gas
71	Acenaphthylene particle	173	Benz(a)anthracene gas
72	Anthracene particle	174	Benzo(a)pyrene gas
73	Benz(a)anthracene particle	175	Benzo(b)fluoranthene gas
74	Benzo(a)pyrene particle	176	Benzo(g,h,i)perylene gas
75	Benzo(b)fluoranthene particle	177	Benzo(k)fluoranthene gas
76	Benzo(g,h,i)perylene particle	178	Chrysene gas
77	Benzo(k)fluoranthene particle	181	Fluorene gas
78	Chrysene particle	182	Indeno(1,2,3,c,d)pyrene gas
79	Non-Methane Hydrocarbons	183	Phenanthrene gas
80	Non-Methane Organic Gases	184	Pyrene gas
81	Fluorene particle	185	Naphthalene gas
82	Indeno(1,2,3,c,d)pyrene particle		

5.3 Changes for the 2014v2 NEI

Three states provided 2014v2 updates to their nonroad inputs: Delaware Department of Natural Resources and Environmental Control, Georgia Department of Natural Resources and North Carolina Department of Air Quality (NCDAQ). See Section 5.5 below for additional details.

5.4 Default MOVES code and database

The nonroad runs were executed using MOVES2014a, the most current publicly-released version of MOVES available at the time. The code version for this release is moves20151201. A modification was made to one Java class (ApplicationRunner) to allow MOVES to run NONROAD2008 on a Linux distributed processing system. This change had no effect on the modeling output and will be included in all future versions of MOVES. The code with the change is referred to as moves20151201a. The default database is movesdb20151201, the same one released publically with MOVES2014a. When NONROAD2008 was incorporated into MOVES, the default data built into NONROAD2008 was converted to MySQL tables and included in movesdb20151201.

5.5 Additional Data: NONROAD County Databases (CDBs)

MOVES uses county databases (CDBs) to provide detailed local information for developing nonroad emissions. The EPA encouraged S/L/T agencies to submit MOVES-NONROAD CDBs to the Emission Inventory System (EIS) for the 2014 NEI. To facilitate the transition from NMIM to MOVES for 2014v1, the EPA also accepted NONROAD inputs in the old format of the NCD. The NCD inputs were converted to CDBs in MOVES format. Data not provided in CDBs is automatically supplied from the MOVES default database. As is also true for MOVES onroad runs, even if an agency submitted fuel or meteorological data, the EPA's values for these data parameters were used. The fuels were those in the MOVES default database for MOVES2014a, movesdb20151201 (see also Section 6.8.2.3). The meteorological data were provided by OAQPS and were derived from a Weather Research and Forecasting Model (WRF) [ref 7] run.

Table 5-3 shows the selection hierarchy for the nonroad data category. The MOVES default database for MOVES2014a (movesdb20151201) and state-submitted inputs in CDBs were used to run MOVES-NONROAD to produce emissions for all states other than California. California-submitted emissions were used.

Table 5-3: Selection hierarchy for the Nonroad Mobile data category

Priority	Dataset	Notes
1	S/L/T-supplied emissions	Several tribes submitted NONROAD emissions. California used their own model, OFFROAD. (Texas ran NONROAD2008 using their data. These data are present in EIS, but were not selected for the 2014NEI. Texas also supplied NCD inputs which were converted and used in MOVESNONROAD)
2	S/L/T-supplied input data from 2014 NEI process	
3	S/L/T-supplied input data from previous NEIs	
4	Movesdb20151201	All data from Movesdb20151201

The EPA asked S/L/T agencies to provide model inputs (CDBs or NCDs) instead of emissions for 2014. However, some agencies also submitted nonroad emissions. Table 5-4 shows the S/L/T agencies that submitted nonroad emissions and/or activity data for the 2014 NEI via the EIS Gateway. The NCDs all went into the database NCD20160513_nei2014v1, which was used to run NMIM to compare with the MOVES-NONROAD runs. Most of the state- and county-specific data in this NCD was converted to CDBs for the MOVES run. The NCD20160513_nei2014v1 database also contained data which had been submitted by S/L/Ts previously, primarily for the 2011 NEI. This S/L/T data were also converted to CDBs for the MOVES-NONROAD runs. Table 5-4 shows all the states for which either CDBs were submitted or created from the NCD20160513_nei2014v1 database. The latter includes those submitted for 2014 and those submitted in earlier NEI processes.

If a CDB was supplied as part of the 2014 NEI process, earlier data from NCD20160513_nei2014v1 that was converted to CDBs was not used. States for which one or more CDBs were created from NCD20160513_nei2014v1 and for which NONROAD files were included are listed in Table 5-5. Only Texas submitted valid NCD data for 2014. Florida submitted a nonroad NCD, but it contained only onroad data. Several allocation files were submitted for Pima County (Arizona) that assigned all of the state's activity to that county, so it was not used. The user-supplied allocation files incorrectly have set the state total surrogates the same as Pima. Since equipment activity and population was not supplied with the Pima submission, the result is that the whole state population is assigned to Pima County. Our solution to this problem was to use the MOVES results for Arizona without rerunning. Although there is probably some good information in the Pima submission, timing prohibited its use. Their submission is for 2014, whereas the default data that was included was for 2002, so changing state totals to match 2002 would not be correct and therefore it was not used.

Table 5-4: Nonroad Mobile S/L/T submissions for the 2014 NEI**

Agency Organization	**State**
2014 Nonroad Emissions	
California Air Resources Board	CA
Coeur d'Alene Tribe	ID
Kootenai Tribe of Idaho	ID
Metro Public Health of Nashville/Davidson County	TN
Nez Perce Tribe	ID
Northern Cheyenne Tribe	MT
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	ID
Texas Commission on Environmental Quality	TX
2014 Nonroad CDB	
Illinois Environmental Protection Agency	IL
New York State Department of Environmental Conservation	NY
North Carolina Department of Environment and Natural Resources	NC
Washington State Department of Ecology	WA
Washoe County Health District	NV
2014 Nonroad NCD*	
Texas Commission on Environmental Quality	TX

* Florida submitted a Nonroad NCD, but it contained only onroad data. Several allocation files were submitted for Pima County that assigned all of the state's activity to that county, so it was not used.

**California and tribal emissions submittals are included in the 2014v2 NEI. All other state/counties used MOVES estimates from EPA model runs, with submitted input.

Table 5-5: States for which one or more CDBs were created from NCD20160513_nei2014v1 and for which NONROAD files were included

Name	**FIPS**	**Pop**	**Act**	**Alo***	**Grw**	**Sea**
Colorado	08			1		
Connecticut	09	X				
Delaware	10	X		17		
Georgia	13			10		
Illinois	17	X	X	2	X	X
Indiana	18	X	X	2	X	X
Iowa	19		X	2		X
Maryland	24	X				
Michigan	26	X	X	2	X	X
Minnesota	27		X	3	X	X
Nevada	32			10		
New Hampshire	33	X				

Name	FIPS	Pop	Act	Alo*	Grw	Sea
New Jersey	34	X				
New York	36			1		
North Carolina	37					X
Ohio	39	X	X	2	X	X
Rhode Island	44	X				
Texas	48	X	X	19	X	X
Washington	53			2		
Wisconsin	55	X	X	2	X	X
* "Alo" is allocation of equipment population from state to county, based on one of 19 possible surrogates. The number in the "Alo" column is the number of files, one for each surrogate. "Act" is activity in hours per year. "Pop" is equipment population. "Grw" is growth of population from a number of base years. MOVES will use the correct surrogate and closest base year. "Sea" (seasonality) is temporal allocation of activity to different seasons. In MOVES, this allocation is by month and state. "FIPS" is the 2-digit Federal Information Processing Standard state code.						

The 320 submitted CDBs used for the MOVES-NONROAD run are collected together in NonroadCDBs.zip in the NRSupplementalData folder. CDBs were used only for states/counties that submitted CDBs or NCDs, including submissions prior to 2014. The rest were run using the MOVES default database, which does not require CDBs. A list of all 3,224 U.S. counties and their corresponding CDBs, if any, is available in nonroad_counties_nei2014v1_FinalList.xlsx. The contents of the NRSupplementalData folder are listed in Table 5-6 and are available on the 2014v1 Supplemental nonroad mobile data FTP site.

Table 5-6: Contents of the Nonroad Mobile supplemental folder

File or Folder	Description
2014v1_NonroadCDBs.zip	Submitted CDBs used to run MOVES-NONROAD.
NonroadCDBs_2014v2_DE_GA_NC_20170824.zip	Submitted CDBs used to run MOVES-NONROAD updated for 2014v2
2014v1_nonroad_counties_nei2014v1_FinalList.xlsx	List of all counties and their CDBs.
2014v1_zonemonthhour2014.zip	Zonemonthhour table (meteorology data).
2014v1_NonroadRunspecs.zip 2014v2_Nonroad_Runspecs_DE_GA_NC.zip	Runspecs for all counties.
2014v1_NmimToMovesConversion.zip	Folder containing two subfolders corresponding to the two steps of the NMIM to MOVES conversion.
2014v1_NCD20160513_nei2014v1_nrextfiles.zip	The NONROAD files from the external files folder of NCD20160513_nei2014v1.
2014v1_postprocess_nrnei_20160523.jar	Post-processing scripts for MOVES runs.
2014v1_EICtoEPA_SCCmapping.xlsx	File mapping California emission inventory codes (EICs) to EPA SCCs.

5.6 Conversion of NMIM NCDs to MOVES CDBs

Conversion from NMIM NCDs to MOVES CDBs was done in two steps. First, the data packets in the NCD ASCII files were converted into intermediate MySQL tables with the same column headings. Second, the resulting MySQL tables were converted into MOVES tables and stored in the correct CDB.

The state- and county-specific custom data files that NONROAD2008 uses are text files that are stored in a folder called ExternalFiles within the NCD. It is these text files that the S/L/T agencies submit. The files are activity (hours per year by SCC and horsepower category), allocation files (allocation of equipment population from state to county level), growth, population, and seasonality (how equipment usage varies with season). These data files may be found in the NCD20160513_nei2014v1_nrextfiles folder in the online NRSupplementalData folder. All the NRSupplemental data and scripts are listed in Table 5-6. The NR external files contain one or more "packets" of data. Table 5-7 shows the data files and the packets they contain. These packets were converted by a Python program (ProcessNRTxtFiles.py) into Intermediate MySQL tables, as shown in Table 5-8.

Table 5-7: Conversion of NONROAD data files to MOVES tables

NR data file	NONROAD data file packet	Intermediate MySQL tables	MOVES tables
Pop	Population	Population*	nrbaseyearequippopulation
Act	Activity	Activity*	nrsourceusetype
Alo	Indicators	Allocation*	nrstatesurrogate
Grw	Indicators Growth Scrappage Alternate scrappage	Growthindicators Growth* Growthscrappage Growthaltscrappage	Nrgrowthindex
Sea	Regions Monthly Daily	Region Monthlyadjfactors* Dailyadjfactors*	nrmonthallocation nrdayallocation

*These are the intermediate MySQL tables that were converted into MOVES tables by the scripts listed in Table 5-8.

Table 5-8: MySQL scripts to convert intermediate to MOVES tables

Script	Comment
GenerateMovesNr_activity.sql	If pop is provided
GenerateMovesNR_activity_nopop.sql	If pop is not provided
GenerateMovesNr_allocation.sql	
GenerateMovesNr_dailyadjfactors.sql	
GenerateMovesNr_growth.sql	Converts only the "Growth" packet
GenerateMovesNr_monthlyadjfactors.sql	
GenerateMovesNr_population.sql	

The intention was to convert all intermediate tables to MOVES tables, but time and resource limitations restricted us to the most important tables. Only Texas submitted NCDs for 2014.

5.7 MOVES runs

In the online NRSupplementalData folder, the Excel® file nonroad_counties_nei2014v1_FinalList.xlsx lists all 3,224 counties and their corresponding CDBs. If no CDB was listed for a county, that county was run with the MOVES default database for MOVES2014a (movesdb20151201). The NRSupplemental Data is listed in Table 5-6.

There were 16 unique state CDBs and 304 unique county CDBs from five states. We constructed the MOVES runspecs so that if a state CDB existed, it was included first, followed by a county CDB. There was only one county with both state and county CDBs. There were 16+304 = 320 CDBs used in the full MOVES-NONROAD run. The CDBs that were used are in nei2014v1_CDBs in the online NRSupplementatalData folder

MOVES was run for each county, using two runspecs: one for diesel equipment, which included horsepower output, and one for all other fuels without horsepower output. All the runspecs are in the NonroadRunspecs folder in the online NRSupplementatalData folder. The MOVES-NONROAD runs were checked for completeness and absence of error messages in the run logs. The output was post-processed to consolidate each county into a single database and to produce SMOKE-ready output. The scripts that performed these processes are in postprocess_nrnei_20160523.jar in the online NRSupplementatalData folder. The MOVES runs created monthly inventories for every U.S. county and post-processing was also done on these monthly outputs.

The following additional steps were taken on the monthly MOVES nonroad outputs to prepare data for loading into EIS:

1. The gas and particle components of PAHs (e.g., Chrysene, Fluorene) were combined.
2. The individual mercury species were combined into total mercury (i.e., pollutant 7439976).
3. Modes for exhaust and evaporative were removed from pollutant names and separated out into the emis_type data field in flat file 2010 files that were then loaded into EIS.
4. Pollutants produced by MOVES but not accepted in the NEI were removed (e.g., ethanol, NONHAPTOG, and total hydrocarbons).
5. Five speciated $PM_{2.5}$ species were added based on speciation profiles (i.e., elemental carbon, organic carbon, nitrate, sulfate and other $PM_{2.5}$). See Section 2.2.5.
6. DIESEL-PM10 and DIESEL-PM25 were added by copying the PM_{10} and $PM_{2.5}$ pollutants (respectively) as DIESEL-PM pollutants for all diesel SCCs. See Section 2.2.5.
7. Airport ground support equipment emissions were removed.
8. Bedford City, Virginia emissions were combined with Bedford County, Virginia emissions.
9. Incorporated California-submitted nonroad emissions.

5.8 NMIM Runs

For comparison purposes, NMIM was run using the NCD20160513_nei2014v1 database. We checked to ensure that no error messages were created during the runs for each geographical area. Furthermore, NMIM generates the same number of output records for each RunID-FIPSCountyID-FIPSStateID-Year-Month combination. Therefore, we confirmed that each output table included the correct number of records for this combination of fields. As with the MOVES runs, the NMIM runs were post-processed to produce monthly inventories for every U.S. county in SMOKE-ready format.

5.9 Quality Assurance: Comparison with NMIM

For the 2014v1 NEI, we compared the MOVES-NONROAD results to the NMIM results. SO_2 was valuable as a comparison species because nearly zero differences in results were expected if activity inputs were the same. Thirty-nine states showed SO_2 differences less than 0.01 percent. Table 5-9 shows the fourteen states that had SO_2 differences greater than 0.01 percent.

Table 5-9: States with absolute percent difference (MOVES-NMIM) > 0.01% for SO_2 exhaust*

State FIPS Code	State	MOVES - NMIM % diff	2014 CDB	NCD
36	New York	-29.743%	X	
4	Arizona	-29.684%		
53	Washington	-24.787%	X	
37	North Carolina	-10.399%	X	
17	Illinois	-9.956%	X	
39	Ohio	7.696%		grw
2	Alaska	6.248%		
27	Minnesota	5.819%		grw

State FIPS Code	State	MOVES - NMIM % diff	2014 CDB	NCD
55	Wisconsin	5.145%		grw
26	Michigan	1.637%		grw
24	Maryland	1.376%		pop
48	Texas	-0.040%		grw
18	Indiana	-0.039%		grw
33	New Hampshire	-0.019%		pop

* Sorted in order of decreasing absolute difference

We investigated the reasons behind the larger observed SO_2 differences. The large differences for states that submitted CDBs (-10 percent to -30 percent, in Illinois, New York, North Carolina, and Washington) are attributed to those submittals. Submitted CDBs were expected to contain different data than NCD20160513_nei2014v1. Some states with differences of 2 percent to 8 percent (Michigan, Minnesota, Ohio, and Wisconsin) are attributed to NCD growth files that were only partially converted to CDBs. There are four data packets in the NONROAD growth file. Due to resource limitations, a conversion script was written for only one of them (see Section 5.6). The region packet in the seasonality file did not require conversion because in MOVES, every state has its own seasonality, as defined in the nrmonthallocation table. The growth packets that were not converted for 2014NEIv1 were converted for the 2014NEIv2.

A NCD for Pima County, Arizona, was submitted, which was used to produce the NMIM results. However, this NCD included allocation files with Pima County allocation surrogates set equal to the state total. The result was that all of the state's emissions were assigned to Pima county, while reasonable allocations were assigned to other counties. Because of this error, the MOVES run was performed without using data from the submittal. As a result, the differences between the MOVES-NONROAD and NMIM-based runs were nearly 30 percent.

In Alaska, between 2007 and 2008, three counties were eliminated and five new ones formed. The eliminated county FIPS codes were 02201, 02232, and 02280. The newly formed county FIPS codes were 02105, 02195, 02230, 02195, and 02198. The NMIM counties were correct, but produced zero emissions for the five new counties. Therefore, MOVES was 6 percent higher. The 24 Alaska counties for which NMIM produced SO_2 emissions agreed exactly with MOVES.

Comparing MOVES and NMIM for states with good agreement in SO_2 (Table 5-10) demonstrates differences due to effects other than activity. Differences in VOC and HAPs were expected since they are both post-processed from THC, and MOVES uses newer emission factor data than NMIM [ref 8]. The HAPs generally increased dramatically, which is reflected in the overall increase shown in the table (the sum of 52 species). NOx increased slightly and CO decreased slightly due to a change in the conversion factor of ethanol volume percent to oxygen weight percent from 0.3448 in NMIM [ref 9] to 0.3653 in MOVES. The direction and small size of these changes was expected. Overall, the changes in criteria air pollutants (CAPs) are small, and provide confidence that the transfer of NONROAD2008 from NMIM to MOVES was successful. We have examined the large changes in HAPs individually and confirmed that these changes agree with our updates.

In addition to the comparison of NMIM and MOVES, county plots of NOx, SO_2, and VOC for of 2014 MOVES were compared and reviewed, along with comparison plots and spreadsheets of 2014 NMIM versus 2011NEIv2. County plots of MOVES nonroad activity hours and population along with plots of NOx emissions per unit activity by nonroad category (agriculture, industrial, lawn and garden, etc.) were also developed and reviewed.

Table 5-10: Comparison of NMIM to MOVES-NONROAD*

Pollutant Code	Pollutant Name	Percent Difference
CO	CO	-1.28%
CO2	CO2	0.98%
NH3	NH3	0.00%
NOX	NOx	0.34%
PM10-PRI	PM10-PRI	0.00%
PM25-PRI	PM25-PRI	0.00%
SO2	SO_2	0.00%
VOC	VOC	-1.68%
200	Mercury Elemental Gaseous	23.64%
201	Mercury Divalent Gaseous	14.58%
202	Mercury Particulate	2.02%
50000	Formaldehyde	103.17%
50328	Benzo(a)pyrene	1122.47%
53703	Dibenzo(a,h)anthracene	1383.69%
56553	Benz(a)anthracene	612.21%
71432	Benzene	26.70%
75070	Acetaldehyde	63.19%
83329	Acenaphthene	675.35%
85018	Phenanthrene	702.97%
86737	Fluorene	494.41%
91203	Naphthalene	300.49%
100414	Ethyl Benzene	61.64%
100425	Styrene	182.84%
106990	1,3-Butadiene	61.39%
107028	Acrolein	306.56%
108883	Toluene	32.78%
110543	Hexane	31.90%
120127	Anthracene	419.28%
123386	Propionaldehyde	49.94%
129000	Pyrene	269.93%
191242	Benzo(g,h,i)perylene	841.48%
193395	Indeno(1,2,3,c,d)pyrene	1065.88%
205992	Benzo(b)fluoranthene	928.25%
206440	Fluoranthene	273.50%
207089	Benzo(k)fluoranthene	989.73%
208968	Acenaphthylene	574.35%
218019	Chrysene	777.29%
540841	2,2,4-Trimethylpentane	149.54%
1330207	Xylene	5.59%
1746016	2,3,7,8-Tetrachlorodibenzo-p-Dioxin	-96.58%
3268879	Octachlorodibenzo-p-dioxin	-100.00%
7439965	Manganese Compounds	-0.13%

Pollutant Code	Pollutant Name	Percent Difference
7440020	Nickel Compounds	-4.50%
7440382	Arsenic Compounds	-84.51%
18540299	Chromium 6+	-97.18%
19408743	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	-99.93%
35822469	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	-99.99%
39001020	Octachlorodibenzofuran	-100.00%
39227286	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	-99.88%
40321764	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	-98.45%
51207319	2,3,7,8-Tetrachlorodibenzofuran	-99.01%
55673897	1,2,3,4,7,8,9-Heptachlorodibenzofuran	-99.98%
57117314	2,3,4,7,8-Pentachlorodibenzofuran	-98.72%
57117416	1,2,3,7,8-Pentachlorodibenzofuran	-99.76%
57117449	1,2,3,6,7,8-Hexachlorodibenzofuran	-99.67%
57653857	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	-99.31%
60851345	2,3,4,6,7,8-Hexachlorodibenzofuran	-99.81%
67562394	1,2,3,4,6,7,8-Heptachlorodibenzofuran	-99.94%
70648269	1,2,3,4,7,8-Hexachlorodibenzofuran	-99.83%
72918219	1,2,3,7,8,9-Hexachlorodibenzofuran	-99.77%

* Differences from the 39 states for which SO_2 was within 0.01%. Positive values mean MOVES is larger.

5.10 Use of California Submitted Emissions

California submitted nonroad emissions for EPA's use in the NEI, and we used these emissions directly. Prior to preparing the emissions for submission, the California Air Resources Board (CARB) updated the mapping of their EICs to EPA's detailed SCCs used for emissions modeling that include the off network, on-network, and brake and tire wear categories. CARB provided their HAP and CAP emissions by county using these more detailed SCCs. The updated version of the mapping is posted with the supplemental data in the Excel file 2014v1_EICtoEPA_SCCmapping.xlsx. In addition, CO_2 data were added to the California data based on EPA estimates, because CO_2 emissions were not provided in the submission. We also speciated CARB total $PM_{2.5}$ and PM_{10} using the same approach as for other states (see Section 5.7) and copied the $PM_{2.5}$ and PM_{10} to DIESEL-PM "pollutants" for all diesel SCCs.

5.11 References for nonroad mobile

1. U.S. Environmental Protection Agency, NONROAD2008a Model, NONROAD Model (Nonroad Engines, Equipment, and Vehicles). Office of Transportation and Air Quality, April 2009.
2. California Air Resources Board, Mobile Source Emissions Inventory - Off-Road Gasoline Motor Vehicles.
3. U.S. Environmental Protection Agency, MOVES2014a: Latest Version of Motor Vehicle Emission Simulator (MOVES).
4. U.S. Environmental Protection Agency, National Mobile Inventory Model (NMIM).
5. U.S. Environmental Protection Agency, Speciation Profiles and Toxic Emission Factors for Non-road Engines, EPA-420-R-15-019, November 2015.
6. Lawrence Reichle, Rich Cook, Catherine Yanca, and Darrell Sonntag. Development of Organic Gas Exhaust Speciation Profiles for Nonroad Spark Ignition and Compression Ignition Engines and Equipment. 2015. *Journal of the Air and Waste Management Association*, 65: 1185-1193.

7. National Center for Atmospheric Research, Mesoscale and Microscale Meteorology Division, Weather Research and Forecasting Model, Boulder CO, June 2008, NCAR/TN-475+STR, A Description of the Advanced Research WRF Version 3.
8. U.S. Environmental Protection Agency, Speciation of Total Organic Gas and Particulate Matter Emissions from On-road Vehicles in MOVES2014, EPA-420-R-15-022, November 2015.
9. U.S. Environmental Protection Agency, EPA's National Inventory Model (NMIM), A Consolidated Emissions Modeling System for MOBILE6 and NONROAD, EPA420-R-05-024, December 2005.

6 Onroad Mobile – All Vehicles and Refueling

6.1 Sector description

Onroad mobile sources include emissions from motorized vehicles that are normally operated on public roadways. This includes passenger cars, motorcycles, minivans, sport-utility vehicles, light-duty trucks, heavy-duty trucks, and buses. The sector includes emissions generated from parking areas as well as emissions while the vehicles are moving. The sector also includes "hoteling" emissions, which refers to the time spent idling in a diesel long-haul combination truck during federally-mandated rest periods of long-haul trips.

The 2014 NEI v1 is comprised of emission estimates calculated based on the MOVES model run with S/L/T-submitted activity data when provided, except for California and tribes, for which the NEI includes submitted emissions.

6.2 Important Changes for 2014v2 NEI

The EPA made several substantial improvements in default data for the 2014v2 NEI that include new 2014 vehicle populations and fleet characteristics, as well as new default vehicle speed distributions and relative hourly and day type VMT distributions at the local level from the CRC A-100 study [ref 1]. In addition, other changes in 2014v2 included new CDB submittals (526 databases) and minor changes to the representative county groups based on the new 2014 age distribution data. Also new for the 2014v2, age distributions for representative county CDBs now reflect a population-weighted average of the member county age distributions. The major changes in default data are described in detail below, and the CDBs and representative county groups are discussed in Sections 6.5 6.8.2.1, respectively.

6.2.1 New 2014 Vehicle Populations and Fleet Characteristics

The 2014v2 NEI uses updated 2014 vehicle populations, source type age distributions, and fuel type fractions created from data purchased from IHS Markit (IHS). Under contract with EPA, ERG purchased the mid-year 2014 vehicle registration database from IHS, which contains a county-level summary of all registered vehicles in the US. IHS retrieves its information from each state DMV, compiles it in-house, decodes the vehicle identification numbers (VINs), and assigns each record a MOVES source type code. The database IHS provided did not include VINs or identify individual vehicles, but rather provided a summary count of the population in each county by parameters including make, model, model year, gross vehicle weight (GVW) class, and other fields. In total, there were over 44 million records in the IHS database that identified 277 million vehicles registered in the US as of July 1, 2014. ERG analyzed and made minor changes to the database, then wrote a program to calculate county-level age distributions and fuel type fractions, to populate the MOVES CDB tables `SourceTypeAgeDistribution` and `AVFT` (i.e., Alternative Vehicle and Fuel Technologies), respectively [ref 2].

EPA used the IHS vehicle population data to create EPA default vehicle population data to be used for areas of the country for which source type populations were not provided in 2014 CDB submittals. In areas for which vehicle population data was provided, EPA still reapportioned the relative populations of cars vs. light-duty trucks (while retaining the magnitude of the light-duty vehicles from the submittals) using the county-specific information from the IHS data. In this way, car and light trucks are treated more consistently from state to state than in previous NEIs.

6.2.2 New Vehicle Speeds and VMT Distributions

The Coordinating Research Council sponsored the A-100 project to develop improved, local inputs of vehicle speeds and VMT distributions for use in MOVES and SMOKE based on vehicle telematics data. The CRC A-100 study concluded several interesting findings, including higher speeds for heavy trucks than light and medium vehicles in peak hours clear differences in speed profiles and VMT patterns across vehicle category and city. A sensitivity case study conducted as part of the CRC work showed an emissions impact of up to 9%, 5% and 14% in VOC, NOX, and PM2.5 respectively, for an annual average day with MOVES Inventory Mode. The emissions sensitivity showed much larger changes at the hourly level. Previous NEIs have used nationwide averages for these inputs in many counties, and v2 uses the MOVES-formatted tables `AvgSpeedDistribution,` `HourVMTFraction,` and `DayVMTFraction` in all CDBs except for New York, because they specifically requested that their submittal data be used instead of data from vehicle telematics. Several states reviewed the CRC A-100 data products specific to their counties and requested that EPA use the new data over their local data. In addition to updating CDBs, the 2014v2 NEI also incorporates SMOKE input files based on the CRC A-100 hourly speeds and diurnal and weekly VMT temporal profiles.

6.3 Sources of data and selection hierarchy

The EPA calculated the onroad emissions for 2014 for all states using the most recently released version of MOVES, MOVES2014a (code version: 20151201, database version: movesdb20161117). The sources of MOVES input data vary by area, representing a mix of local data, past NEI data, and some MOVES defaults. More state and local agencies than ever before submitted local input data for MOVES. The S/L/T agencies that submitted data for 2014 are listed below in Section 6.10. The EPA used programs within the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system that integrate with MOVES to generate the emission inventories in the lower 48 states for each hour of the year. These emissions are summed over all hours and across road types to develop the emissions for the NEI. For areas outside the continental U.S. (AK, HI, Virgin Islands, and Puerto Rico), the EPA ran MOVES in *Inventory Mode* (rather than with SMOKE-MOVES) to directly estimate emissions[12]. For the state of California, the EPA used onroad emissions provided by California based on the EMFAC model.

As in past NEIs, the data selection hierarchy for 2014 favored local input data over default information. For areas that did not submit a MOVES CDB for this NEI, the EPA projected the corresponding CDB from the most recent version (2011 v2) from year 2011 to 2014. In all projected CDBs, the EPA updated the older 2011 vehicle miles travelled (VMT), population, and hoteling activity with new activity specific to 2014, described in Section 6.8.4.

6.4 California-submitted onroad emissions

California is the only state agency for which an onroad *emissions* submittal was used in the 2014v1 NEI and these emissions are unchanged in the 2014v2 NEI. California uses their own emission model, EMFAC, which uses EICs instead of SCCs. The EPA and California worked together to develop a code mapping to better match EMFAC's EICs to EPA MOVES' detailed set of SCCs that distinguish between off-network and on-network and brake and tire wear emissions. This detail is needed for modeling but not for the NEI, because the NEI uses simplified/more aggregated SCCs than used in modeling. This code mapping is provided in "2014v1_EICtoEPA_SCCmapping.xlxs." California provided their CAP and HAP emissions by county using EPA SCCs after applying the mapping. The California-submitted emissions data provided CAPs (including NH_3), HAPs and methane, but did not include CO_2. Therefore, the 2014 NEI includes MOVES-based CO_2 estimates for California. There was one vehicle/fuel type combination included in the CARB data, gas intercity buses (first 6

[12] More information on the Inventory Mode for MOVES2014a is available in the MOVES2014a User Guide.

digits of the SCC = 220141), that did not match to an SCC generated using MOVES, so we mapped it to gasoline single unit short-haul trucks (220152).

CARB estimates onroad refueling emissions outside of the EMFAC model; they provided these to the EPA, and we assigned them to the onroad refueling SCC 2201000062 (Mobile Sources**;** Highway Vehicles - Gasoline; Refueling; Total Spillage and Displacement). The two EIC codes mapped to this SCC are: EIC 33037811000000 (Petroleum Marketing / Vehicle Refueling – Vapor Displacement Losses / Gasoline (Unspecified)) and EIC 33038011000000 (Petroleum Marketing / Vehicle Refueling – Spillage / Gasoline (Unspecified)).

6.5 Agency-submitted MOVES inputs

Many state and local agencies provided county-level MOVES inputs in the form of CDBs. This established format requirement enables the EPA to more efficiently scan for errors and manage input datasets. The EPA screened all submitted data using several quality assurance scripts that analyze the individual tables in each CDB to look for missing or unrealistic data values.

6.5.1 Overview of MOVES input submissions

State and local agencies prepare complete sets of MOVES input data in the form of one CDB per county. One way agencies can ensure a correctly-formatted CDB is to use the MOVES graphical user interface (GUI) county data manger (CDM) importer. With a proper template created for a single county, a larger set of counties (e.g., statewide) can be updated systematically with county-specific information if the preparer has well-organized county data and familiarity with MySQL queries. However, there is no requirement of MySQL experience to prepare the NEI submittal because the user can instead rely on the CDM to help build the individual CDBs one at a time. Table 6-1 lists each table in a CDB and describes its content or purpose. Note that several of the tables are optional, which means that they may be left blank without consequence to a MOVES run's completeness of results. If an optional CDB table is populated, the data override MOVES internal calculations and produce a different result that may better represent local conditions.

Table 6-1: MOVES2014a CDB tables

Table Name	**Description of Content**
auditlog	Information about the creation of the database
avft	Fuel type fractions
avgspeeddistribution	Average speed distributions
county	Description of the county
countyyear	Description of the Stage 2 refueling control program
dayvmtfraction	Fractions to distribute VMT between day types
fuelformulation	Fuel properties
fuelsupply	Fuel differences by month of year
fuelusagefraction	Fraction of the time that E85 vs. gasoline is used in flex-fuel engine vehicles
hotellingactivitydistribution	***Optional table*** – fraction of hoteling hours in which the power source is the main engine, diesel APU, electric APU, or engine-off
Hotellinghours	***Optional table*** – total hoteling hours
hourvmtfraction	Fractions to distribute VMT across hours in a day
hpmsvtypeday	VMT input by HPMS vehicle group, month, and day type (1 of 4 options)

Table Name	Description of Content
hpmsvtypeyear	VMT input by HPMS vehicle group, as annual total (2 of 4 options)
imcoverage	Description of the inspection and maintenance program
importstartsopmodedistribution	***Optional table*** – engine soak distributions
monthvmtfraction	Fractions to distribute VMT across 12 months of the year
roadtype	***Optional table*** – fraction of highway driving time spent on ramps
roadtypedistribution	Fractions to distribute VMT across the road types
sourcetypeagedistribution	Distribution of vehicle population by age
sourcetypedayvmt	VMT input by source use type, month, and day type (3 of 4 options)
sourcetypeyear	Vehicle populations
sourcetypeyearvmt	VMT input by source use type, as annual total (4 of 4 options)
starts	***Optional table*** – starts activity, replacing the MOVES-generated starts table
startshourfraction	***Optional table*** – fractions to distribute starts across hours in a day
startsmonthadjust	***Optional table*** – fractions to vary the vehicle starts by month of year
startsperday	***Optional table*** – total number of starts in a day
startssourcetypefraction	***Optional table*** – fractions to distribute starts among MOVES source types
state	Description of the state
year	Year of the database
zone	Allocations of starts, extended idle and vehicle hours parked to the county
zonemonthhour	Temperature and relative humidity values
zoneroadtype	Allocation of source hours operating to the county
emissionratebyage	Implementation of California standards [not normally part of a CDB but included for NEI because state-specific data is applicable]

S/L/T agencies submitted a total of 1,815 CDBs for the 2014v1 NEI and they submitted one new CDB and updated 525 of the 2014v1 submittals, for a total of 1,816 CDBs for use in 2014v2. Previously for the 2011 NEI, the number of submitted CDBs totaled 1,363 and 1,426 in v1 and v2, respectively. Agencies submitting data through the EIS, provided completed CDBs (i.e., each table populated), along with documentation and a submission checklist indicating which of the CDB tables contained local data. Table 6-2 summarizes these submission checklists, showing the number of counties within each submittal for which the information was local data, as opposed to a default. Empty slots in the table indicate that the state or county did not provide local data for that particular CDB table. The grand totals of counties across all states show that VMT and population (‘HPMSVtypeYear’ and ‘SourceTypeYear’ tables, respectively) were the most commonly provided local data types.

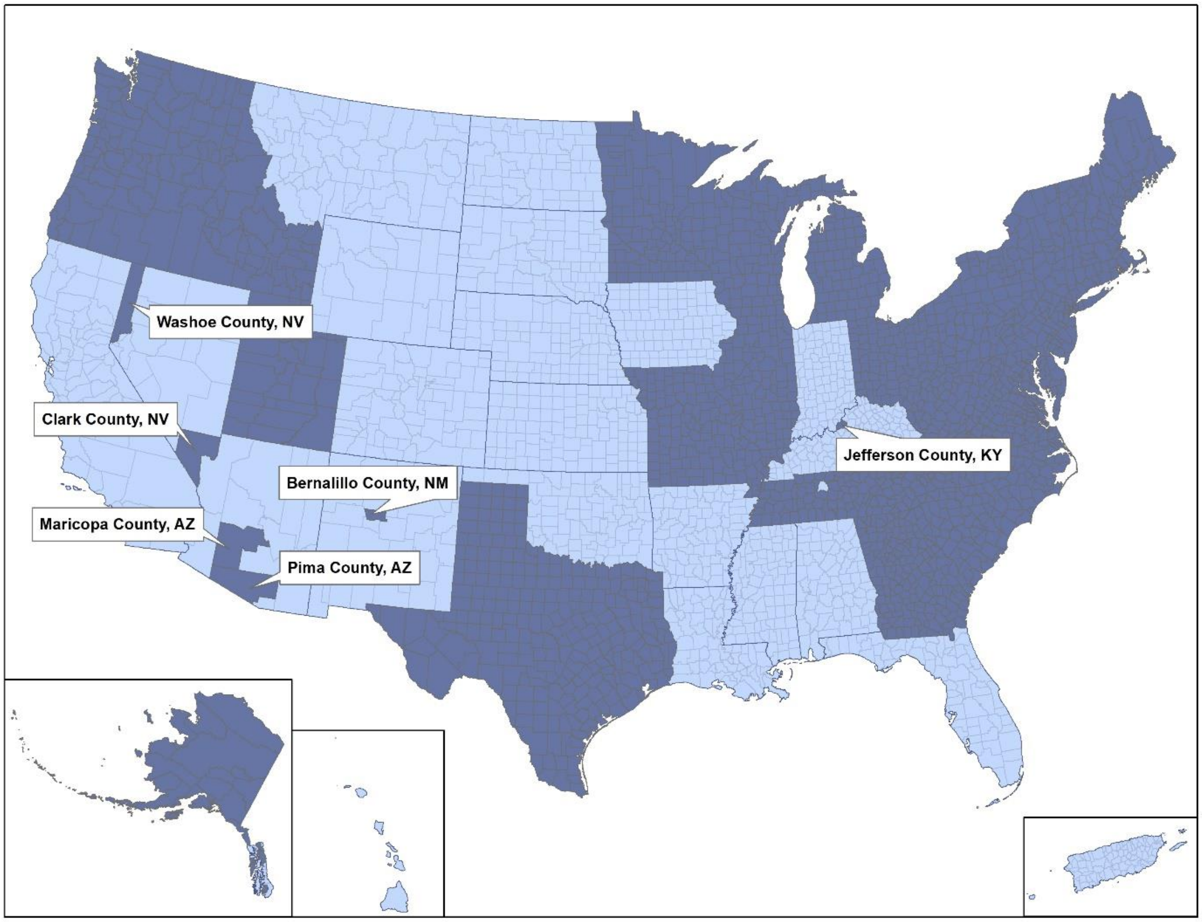
Figure 6-1 shows the geographic coverage of CDB submissions where the state or local agency submitted data that was used for at least one table (dark blue). The light blue areas are counties for which the CDBs were developed by EPA based on the 2011 v2 NEI.

Table 6-2: Number of counties with submitted data, by state and key MOVES CDB table

State/County	avft	avgspeeddistribution	countyyear	dayvmtfraction	emissionratebyage	fuelformulation	fuelsupply	fuelusagefraction	hotellingactivitydistribution	hotellinghours	hourvmtfraction	hpmsvtypeyear	imcoverage	monthvmtfraction	onroadretrofit	roadtype	roadtypedistribution	sourcetypeagedistribution	sourcetypedayvmt	sourcetypeyear	starts	startsperday
Alaska	29											29	1				29	29		29		
Arizona (Maricopa)	1	1	1	1		1	1				1	1	1	1			1	1		1		
Arizona (Pima)	1	1		1							1	1	1	1			1	1		1		
Connecticut	8	8	8	8	8	8	8	8	8	8	8	8	8	8			8	8		8		
Delaware	3		3		3	3	3	3	3	3		3			3						3	3
District of Columbia		1		1							1	1	1	1			1	1		1		
Georgia		24	13	159							24	159	13	159			159	159		159		20
Idaho	44	44		44				44			44	44	2	44			44	44		44		
Illinois		102	102	102		102	102	102			102	102	11	102			102	102		102		
Kentucky (Jefferson)	1	1										1	1				1	1		1		
Maine		16		16		16	16	16			16	16	1	16			16	16		16		
Maryland	24	24	24	24	24	24	24	24			24	24	24	24			24	24		24		
Massachusetts	14	14		14	14	14	14	14	14	14	14	14		14	14					14	14	14
Michigan	7	83		83		7	7	7			83	83	83	83			83	83		83		
Minnesota		87		87							87	87		87			87	87		87		
Missouri	115											115	5					115		115		
Nevada (Clark)											1	1	1	1			1	1		1		
Nevada (Washoe)		1		1		1	1	1			1		1				1	1	1			
New Hampshire			10									10					10	10		10		
New Jersey	21	21	21	21		21	21	21	21	21	21	21	21	21	21		21	21		21		
New Mexico												1						1		1		
New York	62	62	62	62		62	62	62	62	62	62	62	62	62			62	62		62		

State/County	avft	avgspeeddistribution	countyyear	dayvmtfraction	emissionratebyage	fuelformulation	fuelsupply	fuelusagefraction	hotellingactivitydistribution	hotellinghours	hourvmtfraction	hpmsvtypeyear	imcoverage	monthvmtfraction	onroadretrofit	roadtype	roadtypedistribution	sourcetypeagedistribution	sourcetypedayvmt	sourcetypeyear	starts	startsperday
North Carolina		20				1	1				20	100	48				100	100		100		
Ohio	88	88	88	88		1	1	88			88	88	14	88			88	88		88		
Oregon			36				36			36		36	6					36		36		
Pennsylvania		67		67	67	67	67	67			67	67	67	67			67	67		67		
Rhode Island				5							5	5	5	5			5	5		5		
South Carolina												46					46			46		
Tennessee (Chattanooga)	1	1		1	1	1	1	1	1	1	1	1	1	1	1		1	1		1	1	1
Tennessee (Knox)		1		1							1	1		1			1	1		1		
Tennessee (Memphis)	1			1							1	1		1			1	1		1		
Tennessee				91							91	91		91			91	91		91		
Texas	254	254	254	254		254	254		254	254	254	254	254	254		254	254	254		254	254	
Utah	29	29										29	29			29	29	29		29		
Vermont	14											14	14	14				14		14		
Virginia			17				134					134	10	134			134	134		134		
Washington	1			39			1	1			39	39	5	39			39	39		39		
West Virginia												55		55			55	55		55		
Wisconsin		72	9								7	72	7				72	72		72		
Total	**704**	**1006**	**648**	**1064**	**117**	**567**	**738**	**443**	**363**	**399**	**957**	**1816**	**683**	**1267**	**39**	**283**	**1618**	**1754**	**1**	**1813**	**272**	**38**

Figure 6-1: Counties for which agencies submitted local data for at least 1 CDB table are shown in dark blue



6.5.2 QA checks on MOVES CDB Tables

The EPA used two separate quality assurance scripts to scan submitted CDBs and flag potential data errors. The scripts report the potential errors by compiling a list into a summary quality assurance database table. The list of potential errors includes the CDB name, table name, a numeric error code, and in some cases the suspect data value or sum of values that caused the script to flag the particular table. EPA reviewed all of the potential errors, identified which ones needed to be addressed, and then coordinated with the responsible state/local agency to clarify whether the data were correct or needed revision.

The first quality assurance script is one that the EPA updates for each version of the NEI for which states are asked to submit CDBs through the EIS. This script was designed to catch errors that would cause MOVES to fail during a run. The second script was designed to catch unreasonable data values that wouldn't necessarily cause MOVES to fail, but could cause it to produce unreasonable model outputs. Examples of suspected unreasonable values include (a) a mix of vehicle type population or VMT that shows more heavy-duty (HD) vehicles or VMT than shown for light-duty (LD), (b) age distributions that are skewed to older vehicles rather than newer, or (c) atypical VMT temporal patterns such as higher VMT in winter than summer or higher VMT overnight than during daytime.

Nearly 90 percent of the submitted 1,815 CDBs in v1 required at least one update due to missing or incorrect data, incorrect table formatting, or excess data (more than required), which was removed prior to use. The missing or incorrect data included the following problems:

- Missing age distributions for some HD source types (most commonly buses)
- Age distribution for some source types not summing to 1 (e.g., 0.93 or 3.5)
- Negative values in the Hoteling Activity Distribution table
- Missing weekend (day type 2) activity across one or more CDB tables: VMT (via the `SourceTypeDayVMT` table), average speed distributions, hourly VMT fractions, and/or starts per day
- Completely empty or missing source types in the Hour, Day, or Month VMT fractions
- Old inspection and maintenance (I/M) programs included as active, but known to have previously ended
- Incorrect year (e.g., 2013, but should be 2014) in the population table
- Fleet mix too large for HD vehicles (e.g., combination truck population 100 times larger than that of passenger cars)
- All freeways in a state have zero ramps

Nearly 50 percent of the new submitted 526 CDBs for v2 required a correction in order for MOVES to be able to use the database. The following problems were addressed:

- Wrong year listed in one or more tables
- Duplicate entries in the HPMSVtypeYear table
- IMCoverage table covered gasoline but not flex-fuel vehicles
- RoadType table structure not compatible with MOVES2014a
- Expected VMT tables required for MOVES2014a (SourceTypeDayVMT, SourceTypeYearVMT, and HPMSVtypeDay) were missing

The EPA resolved each of the above data problems by coordinating with state/local agencies individually. In some cases, the agency preferred to submit a corrected CDB, which the EPA contractor reviewed again to verify the intended correction. In other cases, the agency provided the EPA with instructions for a “spot correction” to a table or simply accepted the EPA’s proposed update. ERG also corrected formatting problems with the database tables. In some cases, tables had missing data fields and/or table keys; the missing fields did not house important content, but their presence is required for MOVES2014a to run. One state’s table formatting problems were so widespread that we rebuilt the states’ databases using a template MOVES CDB and filled them with the content from the submittal. We also removed the following unnecessary, excess data content from several tables in several states’ submissions:

- 2011 entries for vehicle population, age distribution, and year tables (presumably carried over from 2011 NEI, presented in addition to 2014 data).
- Invalid input road types in the `roadType` CDB table including road types 6, 7, 8, 9 (associated with separating ramps from freeways) and 100 (associated with the MOVES nonroad model) generated by the County Data Manager template.

6.6 Tribal Emissions Submittals

Tribal onroad emissions were submitted and used in the 2014v1 NEI and these emissions are unchanged in the 2014v2 NEI. The submitting tribal agencies are listed in Table 6-3.

Table 6-3: Tribes that Submitted Onroad Mobile Emissions Estimates for the 2014NEI

Coeur d'Alene Tribe
Kootenai Tribe of Idaho
Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California
Nez Perce Tribe
Northern Cheyenne Tribe
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho

6.7 EPA default MOVES inputs

6.7.1 Sources of default data by MOVES CDB table

The EPA used 2014v1 CDBs for counties where agencies did not submit them for 2014v2. The EPA developed new 2014 estimates of VMT, vehicle population, and hoteling at the county- and SCC-level for use in the subsequent SMOKE-MOVES processing step. In the CDBs, we used these v2 activity estimates for 2014 to overwrite any default data. States and counties with CDBs that included 2014 EPA-generated activity and projected CDBs are those indicated by light blue shading in Figure 6-1. Table 6-4 below lists the sources of default information by MOVES CDB table. The spreadsheet 2014NEIV2_Plans_for_CDB_Input_Data_07072017b.xls provides specific information about where state-supplied data were used versus default data. Additional detail on processing steps in the IHS data to create `AVFT` and `SourceTypeAgeDistribution` is provided below in Table 6-4.

Table 6-4: Source of defaults for key data tables in MOVES CDBs

CDB Table	**Default content for 2014v2 NEI**
avft	2014 IHS data
avgspeeddistribution	CRC A-100 study
dayvmtfraction	CRC A-100 study
fuelformulation	Based on EPA estimates for each county from 2014 refinery data
fuelsupply	Based on EPA estimates for each county from 2014 refinery data
fuelusagefraction	MOVES2014a default E85 usage
hotellingactivitydistribution	MOVES2014a default APU vs. Main Engine fractions
hotellinghours	2014 EPA estimates of hoteling based on 2014 VMT
hourvmtfraction	CRC A-100 study
hpmsvtypeday	Empty by default
hpmsvtypeyear	Empty by default
imcoverage	2014 NEI v1
importstartsopmodedistribution	Empty by default
monthvmtfraction	2014 NEI v1
roadtype	2014 NEI v1
roadtypedistribution	EPA estimates based on FHWA
sourcetypeagedistribution	2014 IHS data
sourcetypedayvmt	Empty by default
sourcetypeyear	2014 IHS data, with EPA modification
sourcetypeyearvmt	2014 EPA estimates of VMT based on FHWA data and 2014 IHS data

CDB Table	Default content for 2014v2 NEI
starts	Empty by default
startshourfraction	Empty by default
startsmonthadjust	Empty by default
startsperday	Empty by default
startssourcetypefraction	Empty by default
zonemonthhour	2014 meteorology data averaged by county
emissionratebyage	The `emissionratebyage` tables for some counties were populated using appropriate data described in the guidance for states adopting California emission standards

Preparation of `AVFT` and `SourceTypeAgeDistribution` CDB Tables

As mentioned above in Section 6.2.1, national vehicle population data from IHS were used to derive updated `SourceTypeAgeDistribution` and the alternative vehicle fuel type `AVFT` tables in the CDBs. The IHS data provided county-specific vehicle counts by source type, fuel type, and model year. From these data, two sets of `SourceTypeAgeDistribution` and `AVFT` tables were generated: one set with unique distributions calculated independently for each county, and another set with distributions population-weighted over the 2014v2 representative county groups. The grouped tables were used in the representative CDBs seeded for running MOVES in emission factor mode. The individual county tables were used in the full set of CDBs that are unseeded and appropriate for running MOVES in inventory mode. Both sets of age distribution tables are provided in .csv form with the 2014v2 NEI onroad supporting data (see Table 6-7). More discussion on database seeding can be found in Sections 6.8.6 and 6.8.7.

The IHS data did not contain vehicle counts for every possible source type and county combination, so some gap filling was necessary. Data for *sourceTypeID* 41 (Intercity Bus) were not reliably distinguishable from *sourceTypeID* 42 (Transit Bus) in the IHS data, so we used a county-specific bus age distribution to represent these two bus types for each county. Similarly, source types 52 and 53 (single unit trucks) could not be distinguished, nor could source types 61 and 62. We also calculated national averages for the long-haul source types 53 (Single Unit Long-haul Truck) and 62 (Combination Unit Long-haul Truck) because these vehicles tend to operate regionally or nationally rather than in their county of registration. Missing *countyID/sourceTypeID* combinations were filled using national averages for the *sourceTypeID*. In summary, the following averaging for age distribution was performed:

- Source type 53 (single unit long-haul) and 62 (combination long-haul) age distributions use the IHS national average
- All other source types (11,21,31,32,41,42,43,51,52,54,61) are population-weighted averaged over rep county group
- Source type 41 and 42 have the same age distribution for any given area (because IHS could not reliably distinguish between Intercity vs. Transit Buses)
- Some county groups had missing age distribution for a source type due to no registered vehicles. This happened only for Refuse Trucks (51) and non-school buses (41/42). Where there were no registered vehicles in a county group, the IHS national average age distribution for the source type was used.

The MOVES `AVFT` table defines the fraction of vehicles of a specific fuel type (e.g., gasoline, diesel ethanol-85, electric) for a given source type and model year; the *fuelEngFraction* sums to one for each unique *sourceTypeID/modelYearID* combination. The `AVFT`table fuel type fractions for each county were calculated in a similar manner to the `SourceTypeAgeDistribution` table: the population for each unique *sourceTypeID, modelYearID*, *fuelTypeID*, and *engTechID* combination was divided by the total population for that source type and model year. While light-duty electric vehicles are included in the AVFT table, heavy-duty electric vehicles were not because those combinations are not allowable in MOVES. In addition, any heavy duty E85 and CNG fractions were re-mapped to gasoline vehicles.

For MOVES compatibility, the `AVFT` distributions for certain source type IDs (Intercity Bus and Combination Unit Long-haul Truck) were set to 100% diesel even though other fuel types were present in the IHS data.

EPA's preference was to use the IHS-derived age distributions everywhere unless state agencies opted out. Four states preferred to use their submitted data for the `SourceTypeAgeDistribution` and/or `AVFT` tables submitted for the NEI. Georgia, New Jersey, New York and Ohio CDBs retained the submitted `SourceTypeAgeDistribution` tables and New York retained its submitted `AVFT` tables. The only change to these four states' data was to population-weight the distributions over v2 county groups.

After the `AVFT` tables were created as described above, a final gap filling step was performed to ensure that each existing *sourceTypeID* and *modelYearID* combination with data had listed all allowable *fuelTypeIDs* for MOVES (populated with zeros, rather than missing from the table), which prevents the model from supplementing a CDB `AVFT` distribution that already summed to 1 with model default values. Both the grouped and county-specific age distribution tables are provided in .csv form with the 2014NEIv2 onroad supporting data (see Table 6-7).

6.7.2 Default California emission standards

The EPA populated an alternative MOVES database table 'EmissionRateByAge' in the CDBs for some counties in the states that have adopted emission standards from California's Low Emission Vehicle (LEV) program. Table 6-5 shows which states adopted the California standards and the year the program began in each state. We developed these tables to be consistent with the EPA guidance for LEV modeling provided on the EPA web site [ref 3].

Table 6-5: States adopting California LEV standards and start year

FIPS State ID	State Name	LEV Program Start Year
06	California	1994
09	Connecticut	2008
10	Delaware	2014
23	Maine	2001
24	Maryland	2011
25	Massachusetts	1995
34	New Jersey	2009
36	New York	1996
41	Oregon	2009
42	Pennsylvania	2008
44	Rhode Island	2008
50	Vermont	2000
53	Washington	2009

6.8 Calculation of EPA Emissions

6.8.1 EPA-developed onroad emissions data for the continental U.S.

For the 2014 NEI, the EPA estimated emissions for every county. For the continental U.S., the EPA used county-specific inputs and programs that integrate inputs and outputs for the MOVES model with the SMOKE modeling system (i.e., SMOKE-MOVES) to take advantage of the gridded hourly temperature information available from meteorology modeling used for air quality modeling. This set of programs was developed by the EPA and also is used by states and regional planning organizations to compute onroad mobile source emissions for regional air quality modeling. SMOKE-MOVES requires emission rate “lookup” tables generated by MOVES that differentiate emissions by process (running, start, vapor venting, etc.), vehicle type, road type, temperature, speed, hour of day, etc.

To generate the MOVES emission rates for counties in each state across the U.S., the EPA used an automated process to run MOVES to produce emission factors by temperature and speed for a set of “representative counties,” to which every other county could be mapped, as detailed below. Using the calculated MOVES emission rates, SMOKE selected appropriate emissions rates for each county, hourly temperature, SCC, and speed bin and multiplied the emission rate by activity (VMT, vehicle population, or hoteling hours) to produce emissions. These calculations were done for every county, grid cell, and hour in the continental U.S. and aggregated by county and SCC for use in the 2014 NEI. The MOVES “RunSpec” files (that provide MOVES input data for each representative county) are provided in the supplementary materials (see Table 6-7 for access information).

The EPA used a different approach for states and territories outside the lower 48 states. For Alaska, the EPA ran MOVES in Inventory Mode, during which MOVES computes the emissions instead of emission rates, for every county and month, using county-specific inputs and meteorological data. For Hawaii, Puerto Rico and the Virgin Islands, MOVES was run in Inventory Mode for the months of January and August, with the months of May through September using the August emissions and the other months using January emissions. More information is provided Section 6.8.10.

SMOKE-MOVES tools are incorporated into recent versions of SMOKE and can be used with different versions of the MOVES model. For the 2014 NEI v1, the EPA used the latest publicly-released version: MOVES2014a (version 20151201) [ref **Error! Reference source not found.**]. Creating the NEI onroad mobile source emissions with S MOKE-MOVES requires numerous steps, as described in the sections below:

- Determine which counties will be used to represent other counties in the MOVES runs (see Section 6.8.2.1)
- Determine which months will be used to represent other month's fuel characteristics (see Section 6.8.2.2)
- Create MOVES inputs needed only for the MOVES runs (see Section 6.6). For example, MOVES requires county-specific information on age distributions and inspection-maintenance programs for each of the representative counties.
- Create inputs needed both by MOVES and by SMOKE, including a list of temperatures and activity data (see Section 6.8.4)
- Run MOVES to create emission factor tables (see Section 6.8.8)
- Run SMOKE to apply the emission factors to activity data to calculate emissions (see Section 6.8.9)
- Aggregate the results at the county-SCC level for the NEI, summaries, and quality assurance (see Section 6.8.11)

Some things to note about the 2014v2 NEI that are different from the 2011v2 NEI and 2014v1 NEI are:

- Manganese/7439965 now includes the brake and tire contribution, whereas in 2011v2 NEI, manganese did not include brake and tire contributions.
- Gasoline with 85 percent ethanol (E85) was tracked as a separate fuel in the 2014v1 NEI, while in the 2011v2 NEI, it was combined with regular gasoline.
- Five speciated $PM_{2.5}$ species were added based on speciation profiles (i.e., elemental carbon, organic carbon, nitrate, sulfate and other $PM_{2.5}$). See Section 2.2.5.
- DIESEL-PM10 and DIESEL-PM25 were added by copying the PM_{10} and $PM_{2.5}$ pollutants (respectively) as DIESEL-PM pollutants for all diesel SCCs. See Section 2.2.5.
- Brake and tire PM was tracked separately from exhaust processes, although all non-refueling processes were combined into broader SCCs prior to loading into EIS.
- For Colorado, refueling emissions were removed from all counties for which Colorado reported refueling in the point source data category.

6.8.2 Representative counties and fuel months

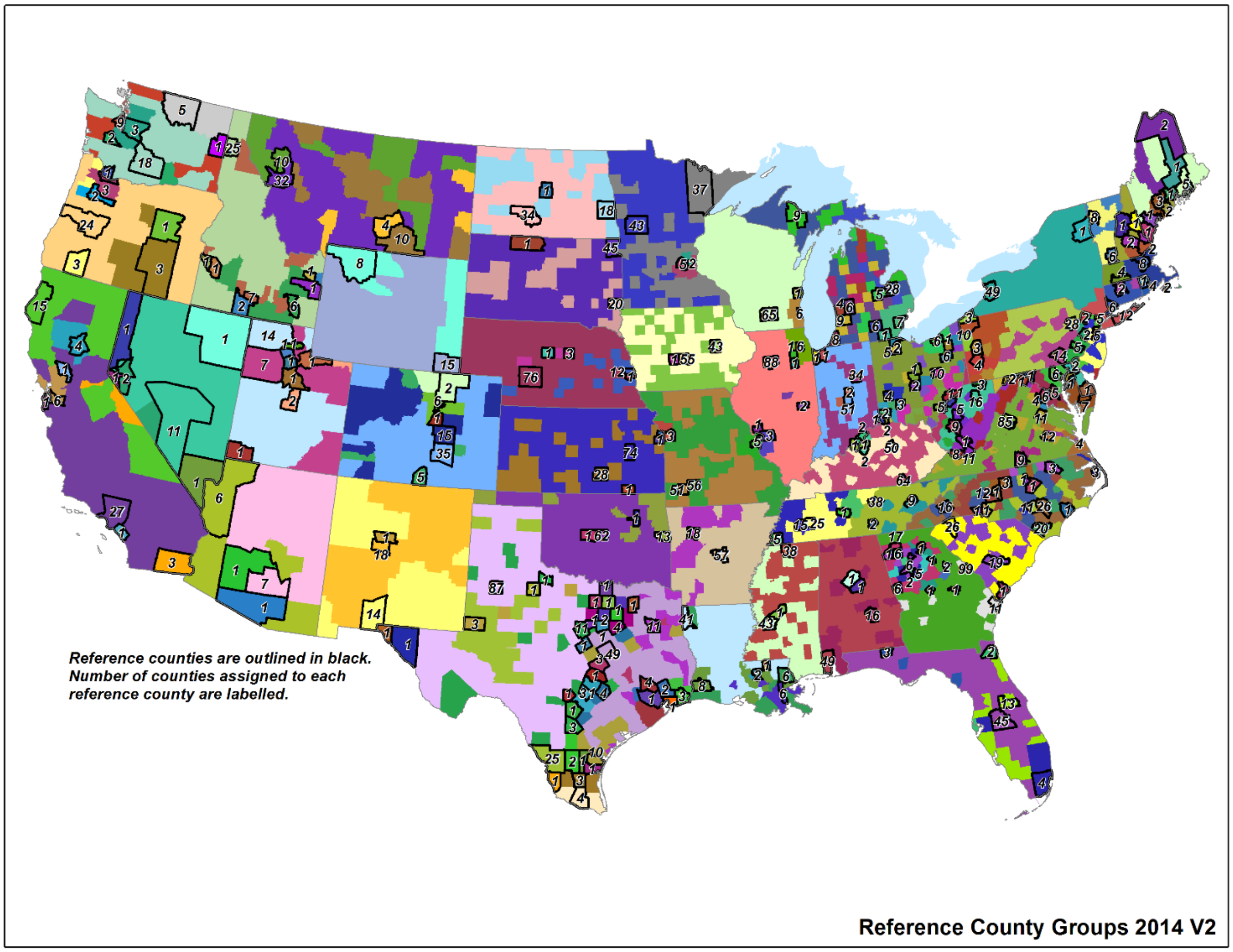
6.8.2.1 *Representative counties*

Although the EPA develops a CDB for each county in the nation, only a subset of these were run with MOVES based on an assumption that most of the important emissions-determining differences among counties can be accounted for by assigning counties to groups with similar properties such as fleet age, a shared I/M program, and shared fuel controls (e.g., low RVP for summer gasoline). The county used to provide emission rates to other counties is called the "representative county." This approach of running MOVES for representative counties helps reduce computation time by reducing the number of MOVES runs to generate a nationwide inventory. The MCXREF file listed in Table 6-6 provides the mapping of each county to its representative county. Usually the same MCXREF file is used for all MOVES processes. However, the emission factors for hoteling Ramsey County, Minnesota were discovered to be zero late in the process of creating the 2014v2 NEI. To address this issue, Anoka and Ramsey County, MN were mapped to use hoteling emission factors from Hennepin County, MN. This additional MCXREF file is listed in Table 6-6 and was only used for hoteling emissions processes.

In the SMOKE-MOVES framework, temperature- and speed-specific data from the emission factor lookup tables generated for the representative counties are multiplied with the county-level activity data for all counties within the corresponding county group. The activity data specific to individual counties in the inventory includes VMT, vehicle population, hoteling hours, and hourly speeds.

The EPA used the 2014 age distributions derived from IHS data to re-evaluate the 2014v1 representative county groups and as a result, added 12 new representative counties for 2014v2. In general, we desired to keep the county groups as similar as possible between 2014v1 and 2014v2. However, we also wanted to ensure that the introduction of new vehicle age data would be reflected in the representative county emission factors appropriately. In some cases, we split 2014v1 county groups when the average age of light-duty vehicles in particular counties was significantly newer or older than vehicle age the rest of the counties in the group. We performed the analysis by first calculating the average age of light duty (LD) vehicles in each county, where LD included the three source types passenger car, passenger truck, and light commercial truck. The average age was then assigned a bin number 1 through 6 according to the following six ranges of 0-7 years old, 7-9, 9-11, 11-13, 13-15, and more than 15 years old. Next, we examined the spread of age bins within the existing v1 county groups. For counties whose age bin became a non-neighboring bin (at least 2 bins away) from the v1 age bin of the group, we moved the county out. For example, if a representative county group was age bin 3 in v1, and the new data resulted in LD average ages of bin 3-6, then bin 3 and 4 were left in the v1 group, and 5 and 6 formed a new county group. Figure 6-2 displays a map of the representative counties by state and their corresponding county groups. The MCXREF file listed in Table 6-7 provides the mapping of each specific county to its representative county.

Figure 6-2: Representative county groups for the 2014 NEI



6.8.2.2 *Fuel Months*

A "fuel month" indicates when a particular set of fuel properties should be used in a MOVES simulation. Similar to the representative county, the fuel month reduces the computational time of MOVES by using a single month to represent a set of months during which a specific fuel has been used in a representative county. Because there are winter fuels and summer fuels, the EPA used January to represent October through April and July to represent May through September. For example, if the grams/mile exhaust emission rates in January are identical to February's rates for a given representative county, and temperature (as well as other factors), then we use a single fuel month to represent January and February. In other words, only one of the months needs to be modeled through MOVES to obtain the necessary emission factors. The hour-specific VMT, temperature and other factors for February are still used to calculate emissions in February, but the emission factors themselves do not need to be created, since one month can sufficiently represent the other month. The fuel months used for each representative county are provided in the MFMREF file in the supplementary materials (see Table 6-7 for access information).

6.8.2.3 *Fuels*

Although state/local-submitted CDBs may have included information about fuel properties, this fuel information was replaced for the MOVES runs for the 2014v2 NEI using fuel properties developed for a set of fuel regions that was generated by the EPA in July 2017 for the 2014v2 NEI (moves201x_2014fuels). The EPA developed these data using a combination of purchased fuel survey data, proprietary fuel refinery information and known federal and local regulatory constraints. Our past analyses of state/local-submitted fuel information has led us to conclude that our replacement of the data is more accurate and the best way to treat all parts of the country consistently with respect to fuel use and the fuel impacts on emission rates. The updated fuel information used for the 2014v2 NEI for calendar year 2014 will be reflected in future versions of the MOVES model.

The steps used to determine the fuel properties in each fuel region are as follows:

1. Fuel properties from proprietary refinery certification data were compiled on a regional basis (based on typical pipeline delivery areas).
2. Properties within a region for finished fuel batches (e.g., no conventional blendstock for oxygenate blending (CBOB), reformulated blendstock for oxygenate blending (RBOB) or oxygen backout (OBO) fuel batches) produced in 2010, excluding reformulated gasoline (RFG), were averaged to generate non-ethanol conventional gasoline fuel properties within that region, for a given month.
3. RFG fuel properties were based on RFG fuel compliance survey data, and oxygenate levels were assumed to be 10 percent ethanol (E10, no MTBE).
4. Refinery modeling results generated for the Renewable Fuel Standard were used to adjust the regional conventional gasoline fuel properties to account for ethanol blending up to E10, for a given month.
5. Additional adjustments to fuel properties were performed on individual counties within a region, based on refinery modeling, for known local regulatory constraints such as low-RVP or oxygenate level mandates.
6. Appropriate E10 and conventional gasoline fuel market shares were calculated on a regional basis for the level of ethanol produced in 2014, after ethanol required for RFG compliance was taken into account.
7. Gasoline fuel properties and ethanol market shares were applied to each county regionally and accounting for known local regulatory constraints.
8. Diesel properties were assumed to be 15 parts per million nationally with no significant biodiesel penetration.

The regional fuel supply database used for the 2014v2 is an external MOVES database called moves201x_2014fuels available for download with the modeling platform (see Section 6.10). A detailed description of the development of the default national fuel supply is provided in the documentation for the MOVES model and on the MOVES Technical Reports webpage [ref 5].

6.8.3 Temperature and humidity

Ambient temperature can have a large impact on emissions. Low temperatures are associated with high start emissions for many pollutants. High temperatures and high relative humidity are associated with greater running emissions due to the increase in the heat index and resulting higher engine load for air conditioning. High temperatures also are associated with higher evaporative emissions.

The 12-km gridded meteorological input data for the entire year of 2014 covering the continental U.S. were derived from simulations of version 3.4 of the Weather Research and Forecasting Model (WRF), Advanced Research WRF core [ref **Error! Reference source not found.**]. The WRF Model is a mesoscale numerical weather p rediction system developed for both operational forecasting and atmospheric research applications. The

Meteorology-Chemistry Interface Processor (MCIP) [ref 7] was used as the software for maintaining dynamic consistency between the meteorological model, the emissions model, and air quality chemistry model.

The EPA applied the SMOKE program Met4moves [ref 8] to the gridded, hourly meteorological data (output from MCIP version 4.3) to generate a list of the maximum temperature ranges, average relative humidity, and temperature profiles that are needed for MOVES to create the emission-factor lookup tables. "Temperature profiles" are arrays of 24 temperatures that describe how temperatures change over a day, and they are used by MOVES to estimate vapor venting emissions. The hourly gridded meteorological data (output from MCIP) was also used directly by SMOKE (see Section 6.8.9).

The temperature lists were organized based on the representative counties and fuel months as described in Section 6.8.2. Temperatures were analyzed for all of the counties that are mapped to the representative counties, i.e., for the county groups, and for all the months that were mapped to the fuel months. The EPA used Met4moves to determine the minimum and maximum temperatures in a county group for the January fuel month and for the July fuel month, and the minimum and maximum temperatures for each hour of the day. Met4moves also generated temperature profiles using the minimum and maximum temperatures and 10 °F intervals. In addition to the meteorological data, the representative counties and the fuel months, Met4moves uses spatial surrogates to determine which grid cells from the meteorological data have roads and uses the WRF temperature and relative humidity data from those areas. For example, if a county had a mountainous area with no roads, the grid cells with no roads would be excluded from the meteorological processing. We updated the spatial surrogates used for the 2014 NEI from those used in the 2011 NEI with 2014 activity such as link-based VMT with the goal of better characterizing the spatial variability of the onroad mobile source emissions. The use of these new spatial surrogates required updates to the cross reference of surrogate assignments by vehicle type and process.

To account for changes in relative humidity, there is a pairing of relative humidity to temperature bins. Met4moves calculated an average relative humidity for the county group for all grid cells that make up that temperature bin. In other words, for all grid cells and hours within a single temperature bin and county group, it extracts and averages the corresponding relative humidity. Met4moves repeats this calculation for each temperature bin and county group, and finally repeats the whole process for each fuel month. When the emission factors are applied by SMOKE, the appropriate temperature bin and fuel month specific relative humidity was used for all runs of the county group. The EPA used a 5 °F temperature bin size for RatePerDistance (RPD), RatePerVehicle (RPV), and RatePerHour (RPH).

Met4moves can be run in daily or monthly mode for producing SMOKE input. In monthly mode, the temperature range is determined by looking at the range of temperatures over the whole month for that specific grid cell. Therefore, there is one temperature range per grid cell per month. While in daily mode, the temperature range is determined by evaluating the range of temperatures in that grid cell for each day. The output for the daily mode is one temperature range per grid cell per day and is a more detailed approach for modeling the vapor venting RatePerProfil (RPP) based emissions. The EPA ran Met4moves in daily mode for the 2014 NEI.

The resulting temperatures for the representative counties are provided in the supplementary materials (see Table 6-7 for access information). The gridded, hourly temperature data used are publicly available only upon request and with provision of a disk media to copy these very large datasets.

6.8.4 VMT, vehicle population, speed, and hoteling activity data

The activity data used to compute onroad mobile source emissions for the 2014 NEI uses EPA defaults where state/local agencies did not provide their own data. These default (but county-specific) data were derived from Federal Highway Administration Data (FHWA) information including the published *Highway Statistics 2014* [ref 9], along with county-level VMT data allocated to vehicle type, fuel type, and road type. Some additional data sources were also used. The development of the default data is described in detail in 2014v2_2014_Default_Onroad_Activity_Data_Documentation.pdf, which is provided with the supporting data in Table 6-7.

As discussed above, SMOKE combines the MOVES emission factors for each representative county with county-specific VMT, population, and hoteling data to compute the emissions for each individual county. These activity data are provided to SMOKE in a flat format, and the source of the data varies according to area of the country and depending on whether the state/local agency submitted data for 2014 NEI.

For the counties for which an agency submitted a CDB (the dark blue areas shown previously in Figure 6-1), the EPA ran scripts to extract the agency-submitted data from the CDBs and reformat it into the flat file text file format that can be input to SMOKE (i.e., FF10). For the non-submitting areas of the U.S. (light blue areas in Figure 6-1), the EPA VMT, population, and hoteling were used. The 2014v2 default speeds are from the CRC A-100 study. The CDBs use a distribution of speeds specific to hour, vehicle and road type, and weekday/weekend day types. SMOKE uses these same data but the 16 speed bin distributions are averaged into an hourly speed, by SCC, county, and weekday/weekend days.

The FF10 creation scripts that read submitted CDBs are described separately by activity type below, followed by discussion on how the EPA created the default 2014 activity data for VMT, population, and hoteling for non-submitting areas.

6.8.4.1 *VMT FF10 file creation*

As for the 2014v2, the FF10-generation scripts read VMT from the MOVES CDB table `sourceTypeYearVMT,` which contains 2014 annual VMT organized by MOVES source type. The scripts disaggregate the source type VMT into fuel type, model year, and road type using a combination of other CDB tables as well as some MOVES default tables. First, the annual VMT is divided into model year using the CDB table with age distribution and the MOVES default database table containing relative annual mileage accumulation by age (`SourceTypeAge`). The scripts use these tables to create travel fractions for each source type and model year that sums to one (1) by source type.

Next, the VMT is further divided into fuel type categories of gasoline, diesel, CNG, E85, and electric vehicles – preferentially by using submitted MOVES CDB tables `AVFT` to determine the split of engine-fuel types by model year and `FuelUsageFraction` to determine the percent of flex-fuel engines that actually use E85. Flex-fuel engines refer to those capable of operating on either E85 or conventional gasoline, the percentage of which could be a function of local availability of the alternative fuel. Because the AVFT and FuelUsageFraction tables are optional tables in a MOVES CDB, they were not always populated in a submitted database. In cases where data werenot provided, the FF10-generation scripts automatically default to MOVES national distributions of fuel types and/or E85 availability, using the `SampleVehiclePopulation` and `FuelUsageFraction` tables of the model default database to fill the missing data. It is worth noting that several states do not have any VMT (or vehicle population) associated with flex-fuel vehicles because they submitted data indicating either no flex-fuel vehicle population or zero E85 fuel supply in the CDB tables. States without E85 in the 2014v2 NEI include

Connecticut, New Jersey, and New York. In the 2011 NEI, all counties had some E85 vehicles because the FF10 script read only MOVES national data, rather than CDB fuel split and E85 availability information.

Finally, the FF10-generation scripts read the CDB table `RoadTypeDistribution` to further split VMT (by fuel type) into the four MOVES road types (urban and rural, restricted and unrestricted access). The scripts aggregate VMT across model years to the SCC level (i.e., MOVES source type, fuel type, and road type) and reports annual and monthly VMT (using the `MonthVMTFraction` CDB table) for each SCC in each county into a consolidated list.

6.8.4.2 *Population FF10 file creation*

The FF10-generation script that creates the SMOKE vehicle population (i.e., VPOP) data operates similarly to the VMT script just described, except that the calculations do not use travel fractions to disaggregate population by model year. First, the script reads the CDB `SourceTypeYear` table, which contains 2014 population by MOVES source type and divides it into model years based on the submitted CDB `SourceTypeAgeDistribution` table. For each vehicle model year, the scripts apportion vehicle populations to fuel types using the submitted CDB tables `AVFT' and `FuelUsageFraction,' or, if no data was provided, uses the national default corresponding data tables described in Section 6.8.4.1.

The FF10 scripts then aggregate population from the model year level back up to the SCC level (MOVES source type and fuel type, and the road type 1). As with the VMT by SCC, there is no E85 vehicle population in Connecticut, New Jersey, or New York due to agency-submitted data describing the local E85 supply as zero.

6.8.4.3 *Speed FF10 file creation*

SMOKE uses speed data for all counties to lookup the appropriate VMT-based emission factors by speed bin and SCC. The FF10 "SPD" input for SMOKE is one of two speed-related inputs; the other, described below, contains hourly speeds by SCC and county, separately for weekdays and weekends. The FF10 speed file for SMOKE contains a single daily average speed by SCC and county for the annual average and each of the 12 months.

The FF10-generation scripts read the CDB table `avgSpeedDistribution,' which contains the fraction of VMT by 16 speed bins for each source type, day type (weekday/weekend), and hour. The scripts calculate a weighted average to arrive at the average day values.

6.8.4.4 *Speed Profile creation*

The speed profile (SPDPRO) input for SMOKE is optional and supersedes the FF10SPD input. The FF10 SPEED file contains average speed data by county and SCC with no time variation, while the SPDPRO contains average speed data by county, SCC, hour, and weekday/weekend. The FF10 SPEED file is read by the SMOKE program Smkinven, and the SPDPRO is read by the Movesmrg program. The values in the FF10 SPEED file are only used by SMOKE-MOVES if a SPDPRO entry is not available. However, regardless of whether or not you have a SPDPRO, SMOKE-MOVES requires that you have an FF10 SPEED file. SMOKE uses speed data for all counties in order to lookup the appropriate VMT-based emission factors by speed bin and SCC. The scripts read the same MOVES CDB tables as used when creating the FF10 SPEED file, though instead of aggregating to a daily average, the scripts preserve the hourly detail. The scripts compile SPDPRO data listing one average speed per hour of day by SCC and county for weekday/weekend day types

6.8.4.5 *Hoteling FF10 file creation.*

Hoteling activity refers to the time spent idling in a diesel long-haul combination truck during federally-mandated rest periods of long-haul trips. Drivers may spend these rest periods with the main engine on, a smaller auxiliary power unit (APU) engine on, plugged into an electric source if available, or simply leave the engine off. MOVES and the NEI track the emissions from hoteling using the main engine idling versus those from APUs separately. SMOKE reads each type of hoteling hours by SCC and matches them to the appropriate MOVES emission factor from the `RatePerHour' lookup table.

Because the 2014 NEI is the first to use the 2014a version of MOVES, it is the first NEI to have the option for agencies to directly provide MOVES with the number of hoteling hours (via the 'hotellingHours' table) and the percent of trucks by model year that use APUs (the 'hotellingActivityDistribution' table). These CDB tables are optional. When they are present, the FF10-generation scripts read them and translate them into the FF10 formats for SMOKE. If they are empty, the FF10-generation scripts calculate the hoteling consistently with the methodology used internally to MOVES when these tables are empty. Thus, the scripts multiply the VMT for diesel-fueled long-haul combination truck VMT on restricted access roads (urban and rural together) and with the national average rate of hoteling, which in year 2014 is estimated by EPA to be 0.027337 hours per mile. The scripts use the MOVES default fractions of APU usage, which in MOVES2014a is zero percent APU usage through model year 2009, and 30 percent APU usage in model years 2010 and later. The remaining hoteling hours are assumed to occur with the main engine on.

For the 2014v2 NEI, an adjustment to hoteling was made to address concerns raised by stakeholders about hoteling hours being artificially concentrated in areas with large amounts of combination truck VMT, but which were not necessarily areas that trucks stopped to take long rest breaks. This is particularly an issue in heavily-traveled urban areas. The hoteling hours per county were compared to the number of truck stop spaces identified in the Shapefile on which the surrogate that spatially allocates hoteling emissions to grid cells is based. This Shapefile was created collaboratively with states during the development of the 2011 NEI. In the analysis, for each county, the maximum number of hoteling hours per year that could be supported by the number of specified parking spaces was computed using the formula:

*max hours / year = number of spaces * 24 hours / day * 365 days / year*

This assumes that all spaces are filled at all hours of the day. The maximum number of hours was subtracted from the number of hours assigned to that county to determine if the county was over-allocated with hoteling hours as compared to the known spots. For counties with at least 2 million over-allocated hours, a manual review of truck stop spaces was conducted using Google Earth. In cases where evidence of additional spaces was found, the number of spaces was adjusted and a factor was computed so that when that factor was multiplied by hours, the max hours per year matched those available with the adjusted number of spaces (i.e., hoteling hours were no longer over-allocated to the county). For the remaining over-allocated counties, no analysis was performed and a factor to adjust the hoteling hours down to match the max hours per year for each county was computed and applied, although it was assumed that any county can support a minimum of 105,120 hoteling hours (i.e., 12 spaces' worth). No adjustments to hoteling hours were made in counties for which hoteling hours were substantially under-allocated as compared to the number of available spots. Ideally, hoteling hours would be properly allocated to counties by someone familiar with traffic patterns in the local area. The spreadsheet used to compare the hoteling hours with available spaces is listed in Table 6-7, along with a separate spreadsheet that estimates the reductions to hoteling emissions for key pollutants.

6.8.5 Public release of the NEI county databases

Two sets of 2014v2 CDBs are available for download: (1) seeded CDBs, which have been altered to produce emission rates for all sources, roads and processes, and (2) unseeded CDBs. Both types of CDBs are available for all U.S. counties, except that the seeded CDBs intended to be used with MOVES Inventory Calculation. The unseeded CDBs are available for all U.S. counties, but that the seeded CDBs are only available for the representative counties. See Table 6-7 for access details.

6.8.6 Seeded CDBs

The seeded county databases can be used with MOVES to generate emission factor lookup tables for SMOKE-MOVES. In order to create them for SMOKE-MOVES modeling, the EPA performed a "seeding" step, whereby values of zero (0) were updated to a small value of 1e-15. This seeding ensures that the lookup tables will be fully populated regardless of whether the representative county itself had activity for all of the categories covered. Seeding is necessary because counties mapping to the representative county may require an emission factor that would otherwise be missing.

6.8.7 Unseeded CDBs

In contrast to the seeded CDBs, the unseeded CDBs do not have any seeding performed on them. This set of CDBs is true to the local conditions. The unseeded CDBs merge the databases that were agency-submitted with the 1,409 default CDBs that were carried over from the 2014v1 with updates based on HIS and CRC study data. The unseeded CDB tables `SourceTypeYearVMT,` `SourceTypeYear,` `HotellingHours,` and `HotellingActivityDistribution` are consistent with the SMOKE-ready files of 2014 VMT, population, and hoteling.

The CDBs created by EPA (i.e., ones for which there was no submittal by S/L/T agencies) include the 2014 default VMT in the 'SourceTypeYearVMT' tables rather than the 'HPMSVtypeYear' tables (used in the past EPA defaults), which are now empty. The 2014 default hoteling information is included in the CDB tables 'HotellingHours' and 'HotellingActivityDistribution.' As in the past NEI, the 2014 EPA-default vehicle populations are included in the 'SourceTypeYear' tables in the non-submitted CDBs.

6.8.8 Run MOVES to create emission factors

The EPA ran MOVES for each representative county using January fuels and July fuels for the range of temperatures spanned by the represented county group and set of months associated with each fuel set (January and July). A runspec generator script created a series of runspecs (MOVES jobs) based on the outputs from Met4moves temperature information for all months of the year. Specifically, the script used a 5-degree temperature bin with the minimum and maximum temperature ranges from Met4moves and used the idealized diurnal profiles from Met4moves to generate a series of MOVES runs that captured the full range of temperatures for the county group for the months assigned to each fuel. The MOVES runs resulted in four emission factors tables for each representative county and fuel month: rate per distance (RPD), rate per vehicle (RPV), rate per hour (RPH), and rate per profile (RPP). After the MOVES runs were completed, the post-processor script Moves2smk converted the MySQL tables into EF files that can be read by SMOKE. For more details, see the SMOKE documentation [ref **Error! Reference source not found.**].

6.8.9 Run SMOKE to create emissions

To prepare the NEI emissions, the EPA first generated emissions at an hourly resolution using more detailed SCCs than are found in the NEI (i.e., by road type and aggregate processes). The Movesmrg SMOKE-MOVES program performs this function by combining activity data, meteorological data, and emission factors to produce gridded, hourly emissions. The EPA ran Movesmrg for each of the four sets of emission factor tables (RPD, RPV, RPH, and RPP). During the Movesmrg run, the program used the hourly, gridded temperature (for RPD, RPV, and RPH) or daily, gridded temperature profile (for RPP) to select the proper emissions rates and compute emissions. These calculations were done for all counties and SCCs in the SMOKE inputs, covering the continental U.S.

The emissions process RPD is for modeling the driving emissions. This includes the following modes (i.e., processes): vehicle exhaust, evaporation, evaporative permeation, refueling, brake wear, and tire wear. For RPD, the activity data is monthly VMT, monthly speed (i.e., SMOKE variable of SPEED), and hourly speed profiles for weekday versus weekend (i.e., SPDPRO in SMOKE). The SMOKE program Temporal takes temporal profiles specific to vehicle type and road type and distributes the monthly VMT to day of the week and hour. Movesmrg reads the speed data for that county and SCC and the temperature from the gridded hourly (MCIP) data and uses these values to look-up the appropriate emission factors (EFs) from the representative county's EF table. It then multiplies this EF by temporalized and gridded VMT for that SCC to calculate the emissions for that grid cell and hour. This is repeated for each pollutant and SCC in that grid cell. The temporal profiles were updated for the 2014v2 NEI based on the CRC-A-100 study.

The emission processes in RPV model the parked emissions. This includes the following modes: vehicle exhaust, evaporative, evaporative permeation, and refueling. For RPV, the activity data is vehicle population (VPOP). Movesmrg reads the temperature from the gridded hourly data and uses the temperature plus SCC and the hour of the day to look up the appropriate EF from the representative county's EF table. It then multiplies this EF by the gridded VPOP for that SCC to calculate the emissions for that grid cell and hour. This repeats for each pollutant and SCC in that grid cell.

The emissions processes in RPH model the parked emissions for combination long-haul trucks (source type 62) that are hoteling. This includes the following modes: extended idle and APUs. For RPH, the activity data is monthly hoteling hours. The SMOKE program Temporal takes a temporal profile and distributes the monthly hoteling hours to day of the week and hour. Movesmrg reads the temperature from the gridded hourly (MCIP) data and uses these values to look-up the appropriate emission factors from the representative county's EF table. It then multiplies this EF by temporalized and gridded HOTELING hours for that SCC to calculate the emissions for that grid cell and hour. This is repeated for each pollutant and SCC in that grid cell.

The emission processes RPP model the parked emissions for vehicles that are key-off. This includes the mode vehicle evaporative (fuel vapor venting). For RPP, the activity data is VPOP. Movesmrg reads the gridded diurnal temperature range (Met4moves' output for SMOKE). It uses this temperature range to determine a similar idealized diurnal profile from the EF table using the temperature min and max, SCC, and hour of the day. It then multiplies this EF by the gridded VPOP for that SCC to calculate the emissions for that grid cell and hour. This repeats for each pollutant and SCC in that grid cell.

The result of the Movesmrg processing is hourly data as well as daily reports for the four processing streams (RPD, RPV, RPH, and RPP). The results include emissions for every county in the continental U.S.

6.8.10 Onroad mobile emissions data for Alaska, Hawaii, Puerto Rico, and the Virgin Islands

Since the meteorological data used by the EPA for running SMOKE-MOVES covers only the continental U.S., the EPA used the MOVES Inventory Mode to create emissions for Alaska, Hawaii, Puerto Rico and the Virgin Islands. These runs used the average monthly hourly temperatures and humidity values derived from the National Climatic Data Center temperature and humidity data for calendar year 2014. The emissions generated by the Inventory Mode MOVES runs characterized all pollutants, including a full set of metals and dioxins.

These emission inventory estimates were not derived using the same SMOKE-MOVES process used for the other counties. Instead, each county was run independently using the Inventory Mode of the MOVES2014a model. This approach directly calculates the inventory in each county using the inputs provided in each of the county databases. For Hawaii, Puerto Rico, and the Virgin Islands, MOVES was run for only January and July due to the relatively modest temperature variation over the year for these islands. All other months were mapped to those months to create an annual estimate of the emissions. Due to the greater meteorological variation in Alaska, MOVES was run for every month of the year.

The MOVES inputs used for these emissions are:

- The MOVES CDM databases,
- The run specifications used to run MOVES, and
- The MySQL database containing the tables that describe the temperatures and relative humidity values used for these states and territories.

These inputs are provided in the supplementary materials (see Table 6-7 for access information).

6.8.11 Post-processing to create annual inventory

For the purposes of the NEI, the EPA needed emissions data by county, SCC and pollutant. The EPA ran SMOKE-MOVES at a more detailed level including road type and emission processes (e.g. extended idle) and summed over road types and processes to create the more aggregate NEI SCCs. The EPA developed and used a set of scripts to combine the emissions from the four sets of reports and from all days to create the annual inventory.

The onroad emissions for Alaska, Hawaii, Puerto Rico and the Virgin Islands, which the EPA generated via MOVES in Inventory Mode were appended to the onroad inventory generated from SMOKE-MOVES to create the final emissions. These estimates are the same in the 2014v1 and 2014v2 NEI. This complete inventory was loaded into the EIS dataset "2014_EPA_MOVES "as the EPA estimates for the onroad sector.

Five speciated $PM_{2.5}$ species were added based on speciation profiles (i.e., elemental carbon, organic carbon, nitrate, sulfate and other $PM_{2.5}$). DIESEL-PM10 and DIESEL-PM25 were also added by copying the PM_{10} and $PM_{2.5}$ pollutants (respectively) as DIESEL-PM pollutants for all diesel SCCs. See Section 2.2.5 for more details.

6.9 Summary of quality assurance methods

The EPA performed a series of checks and comparisons against both the inputs and the resulting emissions to quality assure the onroad inventory. These checks are in addition to the ones described on the underlying CDBs. The following is a list of the more significant checks that were performed:

- The 2014v2 NEI emissions were compared to the 2014v1 and 2011v2 NEI emissions to make sure that all SCCs, counties, and pollutants were covered and as a general quality assurance of the emissions.
- Comparisons of 2014 and 2011 emissions were done using spreadsheets that compared emissions from the two years using (a) groupings at the first 6 digits of the SCC (fuel + MOVES source type) and (b) grouping by light-duty and heavy-duty.
- Maps of county-level NOx, $PM_{2.5}$ and VOC were prepared for each fuel + MOVES source type combination, total light-duty, total heavy-duty, that included maps of the difference between 2014v2 emissions versus 2014v1 NEI and 2011v2 NEI.

The maps and spreadsheets helped to identify areas with suspect activity data or emission factors, and the EPA followed up on any suspect areas to investigate further and resolve problems if any were found.

6.10 Supporting data

Onroad 2014 emissions were computed by EPA estimates based primarily, on input data submitted by state and local agencies and secondarily using EPA-developed input data, except for the state of California. Table 6-6 provides the submittal history of these county databases. The onroad scripts and data files used in the calculations are listed in Table 6-7. The files and datasets listed in Table 6-7 are all available the 2014v1 Supplemental onroad data FTP site.

Table 6-6: Agency submittal history for Onroad Mobile inputs and emissions

Agency Organization	Onroad CDB Submission Date (MM/DD/YYYY)	Onroad Emissions Submission Date (MM/DD/YYYY)	Notes
Alaska Department of Environmental Conservation	V1: 01/14/2016		
Chattanooga Air Pollution Control Bureau	V2: 05/10/2017		
City of Albuquerque (New Mexico) Environmental Health Department	V1: 01/14/2016		
Clark County Department of Air Quality	V1: 01/22/2016		
Coeur d'Alene Tribe*		V1: 01/07/2016	
Connecticut Bureau of Air Management	V1: 01/14/2016		
Department of Energy and Environment (Washington D.C.)	V1: 12/17/2015		
Delaware Department of Natural Resources	V1: 01/15/2016		
Georgia Department of Natural Resources	V1: 12/21/2015 and 05/17/2016 V2: 05/10/2017		
Idaho Department of Environmental Quality	V1: 12/17/2015		
Illinois EPA	V1: 12/01/2015		
Knox County (Tennessee) Department of Air Quality Management	V1: 12/29/2015		
Kootenai Tribe of Idaho*		V1: 01/07/2016	

Agency Organization	Onroad CDB Submission Date (MM/DD/YYYY)	Onroad Emissions Submission Date (MM/DD/YYYY)	Notes
Louisville (Kentucky) Metro Air Pollution Control District	V1: 06/03/2015		
Maine Department of Environmental Protection	V1: 01/26/2016 V2: 05/05/2017		
Maricopa County (Arizona) Air Quality Department	V1: 12/07/2015		
Maryland Department of the Environment	V1: 01/07/2016		
Massachusetts Department of Environmental Protection	V1: 11/23/2015		
Memphis and Shelby County Health Department – Pollution Control	V2: 05/16/2017		
Metro Public Health of Nashville/Davidson County		V1: 01/15/2016	Agency sent VPOP and VMT via email on 6/7/2016.
Michigan Department of Environmental Quality	V1: 01/13/2016		
Minnesota Pollution Control Agency	V1: 12/17/2015 and 04/08/2016		
Missouri Department of Natural Resources	V1: 03/07/2016 and 06/08/2016		
Morongo Band of Cahuilla Mission Indians of the Morongo Reservation, California*		V1: 12/14/2015	
New Hampshire Department of Environmental Services	V1: 12/18/2015 and04/15/2016		
New Jersey Department of Environment Protection	V1: 01/14/2016		
New York Department of Environmental Conservation	V1: 03/14/2016		
Nez Perce Tribe*	V1: 01/07/2016		
North Carolina DEQ, Division of Air Quality	V1: 01/14/2016		
Northern Cheyenne Tribe		V1: 12/01/2015	
Ohio EPA	V1: 01/12/2016 and 03/18/2016		

Agency Organization	Onroad CDB Submission Date (MM/DD/YYYY)	Onroad Emissions Submission Date (MM/DD/YYYY)	Notes
Oregon Department of Environmental Quality	V1: 01/13/2016		
Pennsylvania Department of Environmental Protection	V1: n03/04/2016		
Pima Association of Governments (Tuscon, Arizona)	V1: 01/27/2016		EPA imported the submittal into MySQL tables and renamed the database (to match the NEI naming convention) and removed the empty non-CDB tables.
Rhode Island Department of Environmental Management	V1: 02/11/2016		
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho*		V1: 01/07/2016	
South Carolina Department of Health and Environmental Control	V1: 12/01/2015		
Tennessee Department of Environment and Conservation	V1: 12/15/2015 V2: 05/17/2017		
Texas Commission on Environmental Quality	V1: 01/28/2016	V1: 01/07/2016	Texas emissions are available in EIS, but Texas' inputs are reflected in EPAMOVES results and in the NEI.
Utah Division of Air Quality	V1: 12/01/2016 and 04/01/2016		
Vermont Department of Environmental Conservation	V1: 01/15/2016 V2: 05/19/2017		
Virginia Department of Environmental Quality	V1: 12/21/2015 V2: 05/16/2017		
Washington State Department of Ecology	V1: 12/01/2015 V2: 04/12/2017		
Washoe County (Nevada) Health District, Air Quality Management Division	V1: 01/11/2016 and 05/13/2016	V1: 05/13/2016	

Agency Organization	Onroad CDB Submission Date (MM/DD/YYYY)	Onroad Emissions Submission Date (MM/DD/YYYY)	Notes
West Virginia Division of Air Quality	V1: 12/16/2015		
Wisconsin Department of Natural Resources	V1: 01/15/2016 V2: 05/16/2017		

* Tribal emissions data submitted to EIS were inadvertently not included in the 2014v1 NEI but will be in version 2. Tribal territory emissions are not calculated by EPA, because they are not in the county databases.

Table 6-7: Onroad Mobile data file references for the 2014 NEI

File Name	Description
2014NEIv2_default_onroad_activity_approach_022118.pdf	Describes method used for EPA default VMT, VPOP, and hoteling hours data used in counties for which data were not submitted by S/L/T agencies.
Folder *CDBs_for_all_counties* contains 2014v2CDBs_stXX.zip where XX is the two-digit state FIPS code	"*Unseeded*" CDBs for all counties in the U.S. archived separately by state. These may not produce fully populated emission rates tables across all categories without "seeding". Activity data and age distributions are specific to each county and not aggregated.
2014NEIv2_repCounty_CDBs_seeded_26sep17.zip	"*Seeded*" CDBs for representative counties in the continental U.S. used to develop 2014NEIv2. These should produce fully populated rates tables because values of zero in the MOVES input tables have been updated to small numbers (1e-15). It only includes the approximately 300 rep. counties and does not include AK, HI, VI, or PR. Age distributions are vehicle-population-weighted across all represented counties.
2014v2_onroad_activity_final.zip	All three data types are in FF10 format for SMOKE and are a combination of EPA estimates, agency submittals, and corrections: 1. Vehicle population by county and SCC covering every county in the U.S., 2. VMT annual and monthly by county and SCC covering every county in the U.S., and 3. Hoteling hours annual and monthly by county covering every county in the U.S. including hours of extended idle and hours of auxiliary power units for combination long-haul trucks only.
2014v2_RepCounty_Runspecs.zip	The MOVES2014a run specifications (runspecs) for the representative counties for running MOVES in emissions rate mode (used for SMOKE-MOVES).

File Name	Description
2014NEIv2_RepCounty_Temperatures.zip 2014v2_RepCounty_Temperatures_MOVES_zmh.zip	The temperature and relative humidity bins for running MOVES to create the full range of emissions factors necessary to run SMOKE-MOVES and the ZMH files used to run MOVES. Generated by running the SMOKE Met4moves program.
MFMREF_2014v2_10jul2017_v0.txt	Fuels cross reference (MFMREF) is a table that maps representative fuel months to calendar months for each representative county. The MFMREF file is an input to SMOKE.
2014v1_AKHIPRVI_Runspecs.zip	The MOVES2014 run specifications (runspecs) for all counties in Alaska, Hawaii, Puerto Rico and the Virgin Islands. These are for running MOVES in Inventory Mode.
MCXREF_2014v2_10jul2017_v0.txt MCXREF_2014v2_10jan2018_nf_v2_for_MN.txt	County cross reference file (MCXREF) is a table that shows every US county along with the representative county used as its surrogate. The MCXREF is an input to SMOKE. A special version is used to compute hoteling emissions in Minnesota to correct an issue with hoteling emission factors.
2014NEIv2_speed_spdpro.zip	These data are in FF10 format for SMOKE and are a combination of EPA estimates, agency submittals, and corrections: 1. Average speed in miles per hour, annual and monthly values, by county and SCC covering every county in the U.S. and 2. Weekend and weekday hourly speed profiles (SPDPRO) in miles per hour, by county and SCC covering every county in the U.S.
2014v1_CDB_QA_Checks_MOVES2014a_v1 2014v1_QA_Checks_v8_2December2015.sql	Scripts designed to catch errors that would cause MOVES to fail during a run and to identify unreasonable data values.
generateFF10_from_CDBs.zip populateCDBs_from_FF10.zip •	FF10 generation scripts read CDB tables and produce SMOKE-formatted activity input files for use in SMOKE-MOVES. The SMOKE files include VMT, vehicle population, hoteling hours, speed, and SPDPRO. Populate CDBs from FF10 scripts read SMOKE-formatted activity files: VMT, vehicle population, and hoteling hours, and update the MOVES CDB tables SourceTypeYearVMT, SourceTypeYear, HotellingHours, and HotellingActivityDistribution.
2014v2_EICtoEPA_SCCmapping.xlxs	Maps California EMFAC codes to MOVES SCCs
2014NEIV2_Plans_for_CDB_Input_Data_07072017b.xlsx	Spreadsheet that shows how state-submitted and default data were merged together to prepare 2014NEIv2.

File Name	Description
2014NEI_v2_Representative_Counties_List_20170620_for_documentation.xlsx	Spreadsheet of representative county characteristics.
2014v2_hoteling_by_county_versus_truck_stop_parking_102817.xlsx	Spreadsheet documenting computation of adjustment factors applied to hoteling hours where there were more hours assigned than the available truck stop parking spaces could support.
2014v2_onroad_RPH_reduced_hotelling_comparison.xlsx	Spreadsheet that estimates the change in emissions due to the reduction in hoteling hours.
2014v2_avft_grouped_csvs.zip 2014v2_agedist_grouped_csvs.zip	Grouped AVFT and age distribution .csv files used to compute emission factors for representative counties and to create the CDBs in 2014NEIv2_repCounty_CDBs_seeded_26sep17.zip
2014v2_avft_individual_csvs.zip 2014v2_agedist_individual_csvs.zip	County-specific AVFT and age distribution .csv files appropriate for inventory modeling of specific counties and used to create the CDBs in the folder *CDBs_for_all_counties*

6.11 References for onroad mobile

1. Coordinating Research Council. 2017. Improvement of Default Inputs for MOVES and SMOKE-MOVES. Report No. A-100.
2. Memorandum, ERG, 2017. Analysis of IHS Registration Data and Preparation of WA 5-08 Task 1 Deliverables.
3. U.S. Environmental Protection Agency, LEV and early NLEV modeling information for MOVES2014-20141022
4. U.S. Environmental Protection Agency, MOVES2014a: Latest Version of Motor Vehicle Emission Simulator (MOVES).
5. U.S. Environmental Protection Agency, MOVES Technical Reports
6. National Center for Atmospheric Research, Mesoscale and Microscale Meteorology Division, Weather Research and Forecasting Model, Boulder CO, June 2008, NCAR/TN-475+STR, A Description of the Advanced Research WRF Version 3.
7. Meteorology-Chemistry Interface Processor (MCIP) version 4.3.
8. User's Guide for SMOKE, including MOVES integration tools.
9. Federal Highway Administration, Highway Statistics 2014.
10. MOVES Utility Scripts, and Scripts that interface between SMOKE and MOVES

7 Wildland Fires (Wild and Prescribed Fires) in the 2014 NEI

7.1 Sector description and overview

Wildfires and prescribed burns (Wildland Fires in sum, WLFs) that occur during the inventory year are included in the NEI as event sources. Emissions from these fires, as well as agricultural fires, make up the National Fire Emissions Inventory (NFEI). For the 2014 NFEI, the EPA calculated emissions from agricultural fires separately from WLF emissions as described separately in Section 4.11. This portion of the document describes the calculation of WLF emissions portion of the 2014 NEI. The reader is referred to a draft report [ref 1] for more information, details, and website information for the EPA estimates described in this section.

Estimated emissions from wildfires and prescribed burns in the 2014 NEI (termed in the remainder of this section as the "2014 NEI"—as this section only pertains to WLFs) are calculated from burned area data. Input data sets are collected from S/L/T agencies and from national agencies and organizations. S/L/T agencies that provide input data were also asked to complete the NEI Wildland Fire Inventory Database Questionnaire, which consists of a self-assessment of data completeness. Raw burned area data compiled from S/L/T agencies and national data sources are cleaned and combined to produce a comprehensive burned area data set. Emissions are then calculated using fire emission models that rely on burned area as well as fuel and weather information. The resulting emissions are compiled by date and location.

For purposes of emission inventory preparation, wildland fire (WLF) is defined as "any non-structure fire that occurs in the wildland (an area in which human activity and development are essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities). Wildland fire activity is categorized by the conditions under which the fire occurs. These conditions influence important aspects of fire behavior, including smoke emissions. In the 2014 NEI, data processing is conducted differently depending on the fire type, as defined below:

Wildfire (WF): "any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire."

Prescribed (Rx) fire: "any fire intentionally ignited by management actions in accordance with applicable laws, policies, and regulations to meet specific land or resource management objectives." Prescribed fire is one type of fuels treatment. Fuels treatments are vegetation management activities intended to modify or reduce hazardous fuels. Fuels treatments include prescribed fires, wildland fire use, and mechanical treatment.

Agricultural burning is a type of prescribed fire, specifically used on land used or intended to be used for raising crops or grazing. This is dealt with in a different section of this document.

Pile burning is a type of prescribed fire in which fuels are gathered into piles before burning. In this type of burning, individual piles are ignited separately. Pile burn emissions are not currently included in the NEI due to lack of usable data and methods. EPA continues to work to develop methods for estimating emissions of this source type.

Table 7-1 lists the Source Classification Codes (SCCs) that define the different types of WLFs in the 2011 NEI, both for EPA data and for S/L/T agency data. The leading SCC description for these SCCs is "Miscellaneous Area Sources; Other Combustion - as Event". In the 2014 NEI, the EPA has compiled WLF emissions by smoldering and flaming phases. The SCCs shown in are used to denote this differentiation. There are six valid SCCs for events in

EIS. The four rows with "EPA Generated?" equals "Yes" are the SCCs into which EPA and S/L/Ts generally compile their data in the 2014 NEI. EPA only generates estimates for these four SCCs.

Table 7-1: SCCs for wildland fires

SCC	Description	EPA Generated?
2810001000	Forest Wildfires; Total (Smoldering + Flaming) for Wildfires	
2810001001	Forest Wildfires; Smoldering	Yes
2810001002	Forest Wildfires; Flaming	Yes
2811015000	Managed Burning, Slash (Logging Debris); Pile Burning	
2811015001	Prescribed Forest Burning; Smoldering	Yes
2811015002	Prescribed Forest Burning; Flaming	Yes

7.2 Sources of data

The WLF EIS sectors include data only from two components: S/L/T agency-provided emissions data for Georgia and Washington (day-specific data in Events format), and the EPA dataset created from SmartFire version 2 (SF2), which used available state inputs. This merged information is the basis of the WLF 2014 NEI. The hierarchy of data used to compile the 2014 NEI was very straightforward: Georgia's and Washington's data comes first, followed by EPA's dataset, as shown in Table 7-2. The NEI includes only Georgia and Washington-provided data for that S/L/T; in other words, there were no additions with any EPA-based data. Georgia was supplied HAP to VOC ratios which they used to estimate HAPs based on their VOC emissions to calculate HAP emissions, so that these emissions calculations were used consistent with what was used for the remainder of the U.S. via the EPA methods.

In 2014, no tribes submitted WLF emissions data, and the EPA did not assign any fires based on the tribal land boundaries. These fires were assigned to the states within which the tribal lands fall. One tribe did submit activity data, which was used in the processing of those data into emissions for that State.

Table 7-2: 2014 NEI Wildfire and Prescribed Fires selection hierarchy

Priority	Dataset Name	Dataset Content	Is Dataset in EIS?
1	State/Local/Tribal Data	Submitted data as discussed above	Yes
2	2014EPA_EVENT	Emissions from SFv2	Yes

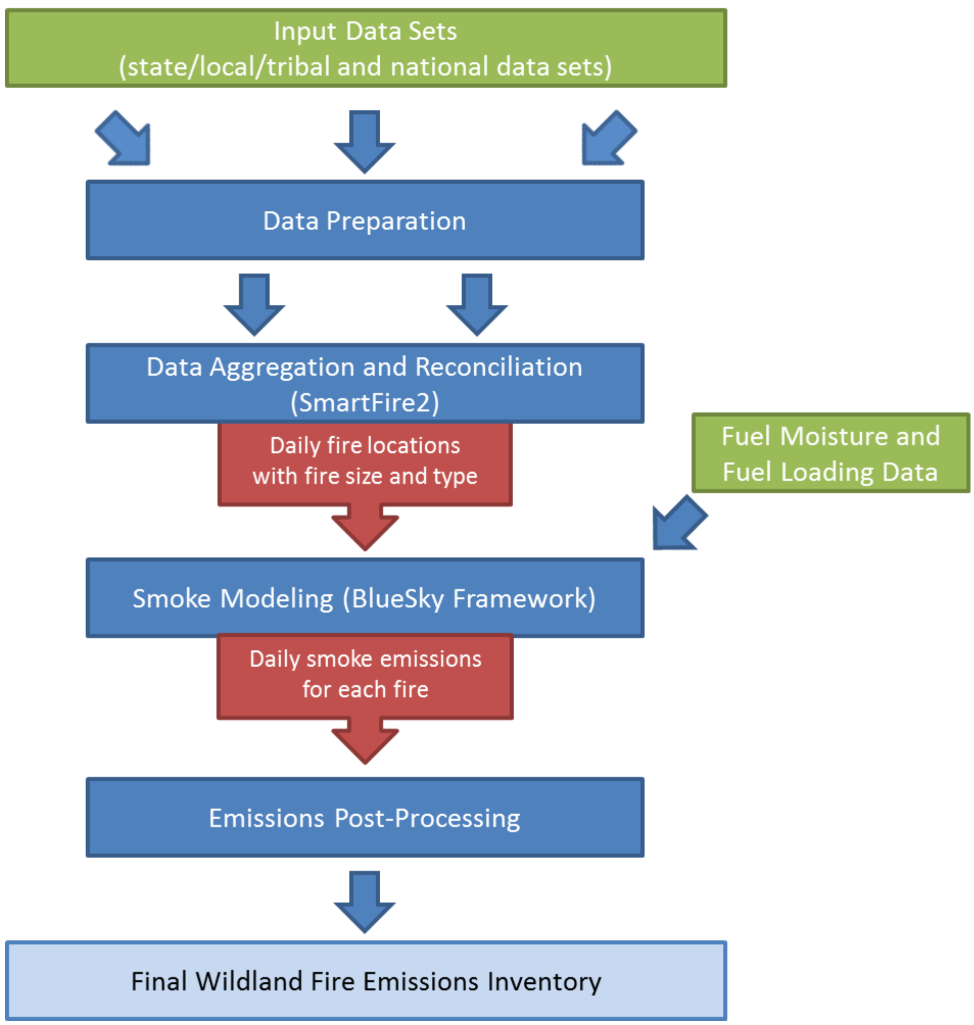
7.3 EPA methods summary

Preparation of the EPA WLF emissions begins with raw input data and ends with daily estimates of emissions from flaming combustion and smoldering combustion phases. Flaming combustion is combustion that occurs with a flame. Flaming combustion is more complete combustion and is more prevalent with fuels that have a high surface-to-volume ratio, a low bulk density, and low moisture content. Smoldering combustion is combustion that occurs without a flame. Smoldering combustion is less complete and produces some pollutants, such as $PM_{2.5}$, VOCs, and CO at higher rates than flaming combustion. Smoldering combustion is more prevalent with fuels that have low surface–to-volume ratios, high bulk density, and high moisture content. Models sometimes differentiate between smoldering emissions that are lofted with a smoke plume and those that remain near the ground (residual emissions), but for purposes of the 2014 NEI v1 those emissions are combined under smoldering emissions of fire. The emissions estimates were estimated and compiled separately for flaming and smoldering combustion phases of fire to facilitate climate modeling and fine-scale research in areas such as health impacts of smoke emissions.

Figure 7-1 shows the sequence of processing steps. First, input data sets are obtained from S/L/T agencies and national sources. The data sets are cleaned to eliminate errors and to standardize formatting for the data. Data sets submitted by various S/L/T agencies are appended together for subsequent processing. Appropriate cleaned data sets from S/L/T agencies and national sources are selected on the basis of data availability, data completeness, and geographic area; they are then reconciled into a single, comprehensive daily fire location data set using SmartFire2. These daily fire locations, along with fuel moisture and fuel loading data, are used by the BlueSky Framework [ref 2] to estimate fuel consumption and smoke emissions. Emissions are then computed for use in the 2014 NEI.

While Figure 7-1 shows a single processing stream, the 2014 NEI for wildland fires was prepared using six separate streams that covered different geographic areas [ref 1]. Each of the streams was processed in a similar manner, with some modification of the smoke modeling approach for fires in Hawaii and Puerto Rico (these modifications are discussed later in this section). Finally, the outputs from all of the streams were compiled into the NEI.

Figure 7-1: Processing flow for wildland fire emission estimates in the NEI



7.3.1 Activity data

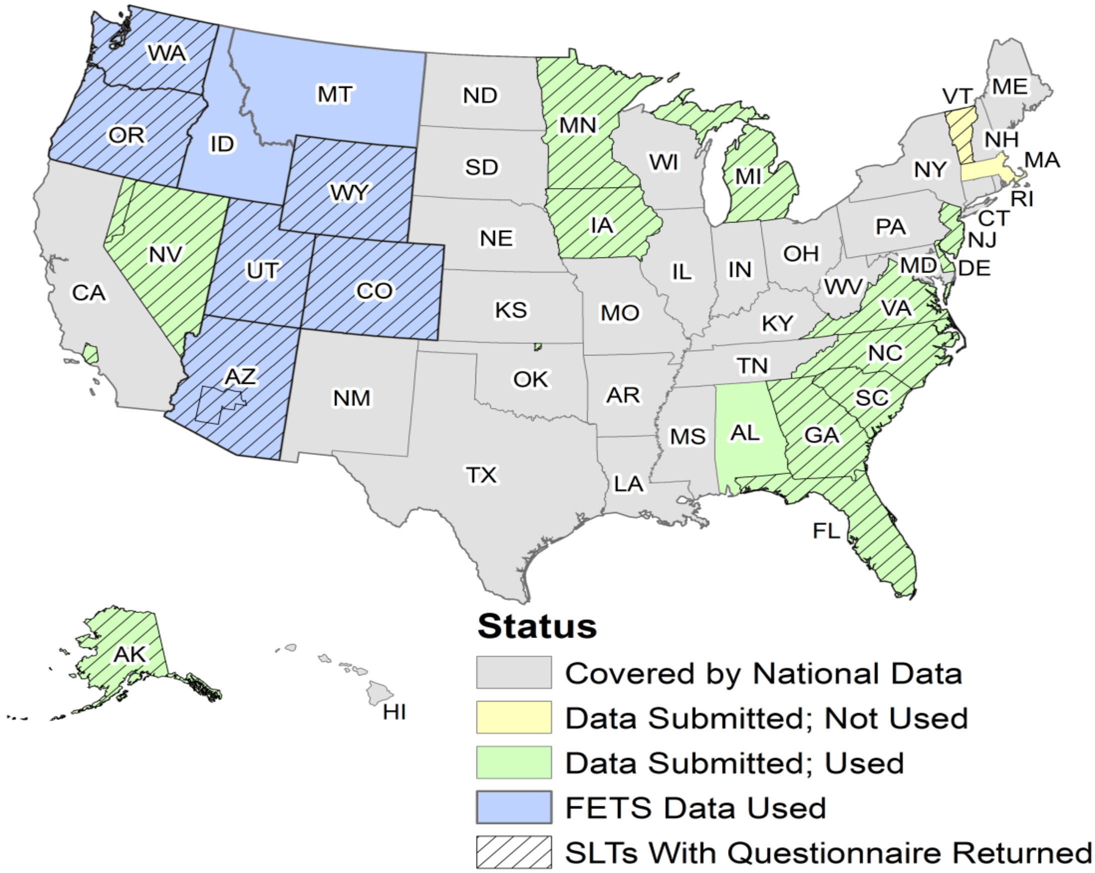
In addition to S/L/T submitted data and national default data sets, auxiliary data for fuel loading and fuel moisture were obtained [ref 1] to support emission calculations.

7.3.2 State, Local, and Tribal fire activity

In spring 2015, S/L/T agencies were invited by EPA and USFS to submit all fire occurrence data in any format for use in developing the 2014 NEI. In winter 2015, the submitting agencies were asked to self-assess the completeness of their data by completing the NEI Wildland Fire Inventory Database Questionnaire [Appendix A in ref 1] Overall, the EPA used a total of 54 data sets from 22 individual states and one Indian Nation. Twenty of the 22 states and the Indian Nation responded to the questionnaire. At a minimum, input data were required to include information about the date, location, fire type, and size of individual fires. Of the 54 data sets, eight were excluded from the NEI because they were determined to lack the minimum descriptive information necessary. Fourteen additional data sets were not used because they were duplicated by regional data from the Fire Emissions Tracking System (FETS). FETS wildland fire information was obtained from the Western Regional Air Partnership (WRAP) through EPA. The FETS data set included fire activity for eight states: Arizona, Colorado, Idaho, Montana, Oregon, Utah, Washington, and Wyoming.

As a result of the data collected and assessed, fire activity data from 22 states and one Indian Nation (32 individual data sets and FETS data) were included in the 2014 NEI. Figure 7-2 shows the states that submitted fire activity data and questionnaire responses, and identifies states where data were incorporated into the 2014 NEI v1. In the figure, states shown in green (as well as the Kaw Nation in Oklahoma and counties in California, Nevada, and Arizona) submitted usable data; blue colored states provided usable data via FETS; yellow colored states submitted unusable data; gray colored states did not provide data; and states shown with lines responded to the database questionnaire.

Figure 7-2: The coverage of state-submitted fire activity data sets



7.3.2.1 National fire activity data sources

In addition to the data provided by S/L/T agencies, fire data sets with national coverage from the following sources were also used to develop the 2014 WLF NEI:

- **Hazard Mapping System (HMS) data** published by the National Oceanic and Atmospheric Administration (NOAA)were acquired and agricultural fires were removed. See Section 4.11 on agricultural fires for more a description as to what was done and why.
- **Incident Status Summary (ICS-209) Reports** in application (.exe) format were acquired via the National Fire and Aviation Management Web Applications website. Upon execution, the application file created a Microsoft Access database containing the fire activity data. Data from two tables in the database were merged and used: the *SIT209_HISTORY_INCIDENT_209_REPORTS* table contained daily 209 data records for large fires, and the *SIT209_HISTORY_INCIDENTS* table contained summary data for additional smaller fires.
- **U.S. Fish and Wildlife Service (USFWS) fire information data** were provided by the USFWS.
- **National Association of State Foresters (NASF) fire information data** were downloaded from the National Fire and Aviation Management Web Applications website. Only wildfire data were included.
- **Forest Service Activity Tracking System (FACTS) fire information data** were supplied by the USFS. Only fuel treatment data were included.
- **Geospatial Multi-Agency Coordination (GeoMAC) fire perimeter data** were downloaded via the USGS GeoMAC wildland fire support website.

- **U.S. Department of the Interior (DOI) prescribed fire data** were extracted from the National Fire Plan Operations and Reporting System (NFPORS) and supplied by the USFS. This is a new data source that was not used in previous efforts. See [ref 1] for more details.

7.3.2.2 Ancillary activity data sources

The fire emission modeling framework used in processing the NEI requires information about burned fuels to estimate emissions. Two key parameters for computing burned fuel, fuel moisture observations and fuel loading were obtained for use in subsequent processing:

- **Fuel moisture:** Fire weather observation files (fdr_obs.dat) were downloaded for each analysis day from the USFS archive on 2/19/2016 and used as inputs to the Fuel_Moisture_WIMS module in the BlueSky Framework [ref 3].
- **Fuel loading:** The Fuel Characteristic Classification System (FCCS) 1-km fuels shapefile and lookup table for the contiguous United States were provided by the USFS AirFire Team. The Alaskan FCCS 1-km fuels shapefile and lookup table were acquired from the USFS Fire and Environmental Research Applications Team's website. Fuels information for Hawaii and Puerto Rico were not required as estimated fuel loadings available in the Fire Inventory from the National Center for Atmospheric Research (FINN) module [ref 4] were used.

7.4 Data preparation and processing

The raw input data were reviewed to determine whether the necessary information was included in each data set. At a minimum, input data were required to include information about the date, location, fire type, and size of individual fires. At a minimum, valid input data were required. Data sets that included at least the minimum required information were examined for data quality and, in cases where the minimum data quality criteria were not met, the invalid data points were modified or removed [see ref 1 for more details on these algorithms]. Agricultural and pile burns were removed from data sets during data preparation or after emission estimation because agricultural burns were processed separately by EPA, and usable pile burn data and a general method for estimating pile burn emissions for the purpose of the NEI were lacking.

7.4.1 S/L/T data preparation

Each S/L/T data set and any accompanying metadata were reviewed to determine its coverage and included information. Eight data sets were excluded from subsequent processing because the data sets lacked the required minimum information (see Appendix B in ref 1). Data sets containing a valid end date value for fires were also noted, and fire durations were calculated when available. All S/L/T data sets were cleaned to:

- include only fires falling within the relevant geographic boundary,
- include only fires with valid start dates falling within 2014 (unless end date is in 2014, in which case fires that started in 2013 were retained),
- include only fires with a valid area greater than zero (0) acres,
- remove agricultural fires,
- remove pile burns,
- modify invalid end dates by changing invalid end dates to be the same as the start date (end dates were considered to be invalid if they fell before the start date, if they fell more than three weeks after the start date for prescribed fires, or if they fell more than one week after the start data and had an area less than 10 acres),
- standardize column names,

- add a unique ID field and populate the field with unique IDs,
- transform point locations provided in projected coordinate systems to geographic coordinates,
- combine all data sets for each state into a single state data set.

Besides these cleaning steps, data sets were visually reviewed and, where warranted, further adjusted. Adjustments included changing the sign of longitude values for Alabama data to ensure that fires fell in the western hemisphere, and manually cleaning various issues with location information for the Iowa data set. Additional minor adjustments to individual fire records were made to correct assumed typos in key fields, including latitude, longitude, and date. An example of such an adjustment would be changing the start date of a fire from 04/05/2015 to 04/05/2014 where the end date was provided as 04/06/2014. Manual review of the data sets was assisted by the creation of an automated report for each data set showing the number of valid fire records that was located within the relevant geographic boundary and occurred during 2014, the geographic distribution of fires and fire types, the distribution of fire start date, the distribution of fire end date and duration where applicable, and the distribution of fire size.

The FETS regional data set was adjusted using the steps outlined above. However, additional preparation was required for the Oregon fire data sets. First, the Oregon wildfire data set was found to have a large number of fires outside the state. The locations of these fires were corrected. Second, the locations of prescribed fires statewide were reported in township/range/section format rather than as geographic coordinates. To identify an approximate location for these fires, we used the Bureau of Land Management GeoCommunicator Township Geocoder Web Service to assign an approximate geographic location for these fires based on the description of the fire location that was supplied in township/range/section format.

Six states and one local agency submitted data independently but were also covered by FETS regional data. Each submitted state or local data set was compared to the available FETS data. The state and local data duplicated the FETS data exactly in all cases. For these jurisdictions, we used FETS data in place of state- or local-submitted data.

S/L/T data sets were assessed for completeness based on the information included on the Database Questionnaire. Data submitters reported the data inclusion level (e.g., always or sometimes) and estimated percent completeness of data sets in categories based on fire types, primary agencies or actors, and land ownerships. The responses, along with any additional input from data submitters, were used to determine which national data sets would best supplement the S/L/T data, if any.

Data sets representing 14 states and one Indian Nation were reported as incomplete across multiple categories, and subsequent processing included all available national data sets as supplemental data. These S/L/T data sets were merged into a “supplement with all” data set for subsequent processing. Also included in the “supplement with all” category were three states that did not respond to the data questionnaire but submitted data that met the minimum requirements for necessary fire information.

The following five states included either no national data sets or only a subset of available national data sets as supplementary data, according to state feedback

- South Carolina. The South Carolina data sets were reported as 100% complete for all categories and as a result, the data sets were not supplemented with any national data sets.
- Alaska. Similarly, Alaska reported 100% completeness for its data set. However, because each raw data record represented a single wildfire over its entire spatial and temporal extent, we supplemented the data for Alaska with the HMS data set to provide improved fire growth and location information. Any resulting fires that were solely based on HMS data were removed in subsequent processing.

- Georgia. The Georgia questionnaire reported that fires associated with a federal primary agency were not included, so only federal data (USFWS, FACTS, NFPORS, and federally reported GeoMAC) were used to supplement the state's data. However, the EPA-estimated emissions through this approach were ultimately not used in the NEI because Georgia elected to submit their own emissions.
- Florida. On the basis of Florida's questionnaire response, its data set was supplemented with federally reported wildfires only in the USFWS and GeoMAC data sets.
- North Carolina. At the state's request, the North Carolina data set was supplemented with only the FACTS data and USFWS data for Pee Dee and Great Dismal Swamp National Wildlife Refuges.

7.4.2 National data preparation

National data sets were prepared in a process similar to the state data set processing: data sets were checked to ensure the minimum necessary information was included, data sets were cleaned, and data set formats were standardized. Some data set-specific cleaning was also performed. Typical cleaning steps included correcting or removing fire locations outside the United States, correcting poorly formatted dates, and correcting end dates that fell either before the start date or an implausible length of time after the start date.

7.4.3 Event reconciliation and emissions calculations

Once S/L/T and national fire activity data were reviewed and cleaned, they were imported into the SF2 data platform for association and reconciliation to remove duplicate fires and assimilate into daily fire locations with fire size and type information. In addition, to develop the 2014 EPA estimates, comments received from all of the states that submitted comments on the 2014 draft emission estimates were addressed to the extent possible. The final step was that the SF2 output was then processed through the BlueSky Framework to estimate fuel loading, fuel consumption, and ultimately smoke emissions for each daily fire location. These smoke estimates were post-processed and compiled into the final wildland fire emissions inventory. Please consult the STI documentation [ref 1] for more details on these steps and how the hierarchy and reconciliation was implemented.

7.4.4 BlueSky Framework emissions modeling

Daily fire emissions were calculated from daily fire location files using the BlueSky Framework. The framework supports the calculation of emissions using various models depending on the available inputs as well as the desired results. Data for the NEI was calculated by using two different model chains based on the location of the fire. The contiguous United States and Alaska, where FCCS fuel loading data are available, were processed using the modeling chain described in Figure 7-3. Hawaii and Puerto Rico, which do not have FCCS fuel loading information available, were processed using a different modeling chain (Table 7-3, Figure 7-3). See Appendix C in ref 1 for a full description of the Bluesky Framework modeling process.

Figure 7-3: Model chain for the contiguous United States and Alaska portion of the 2014 national wildland fire emissions inventory development

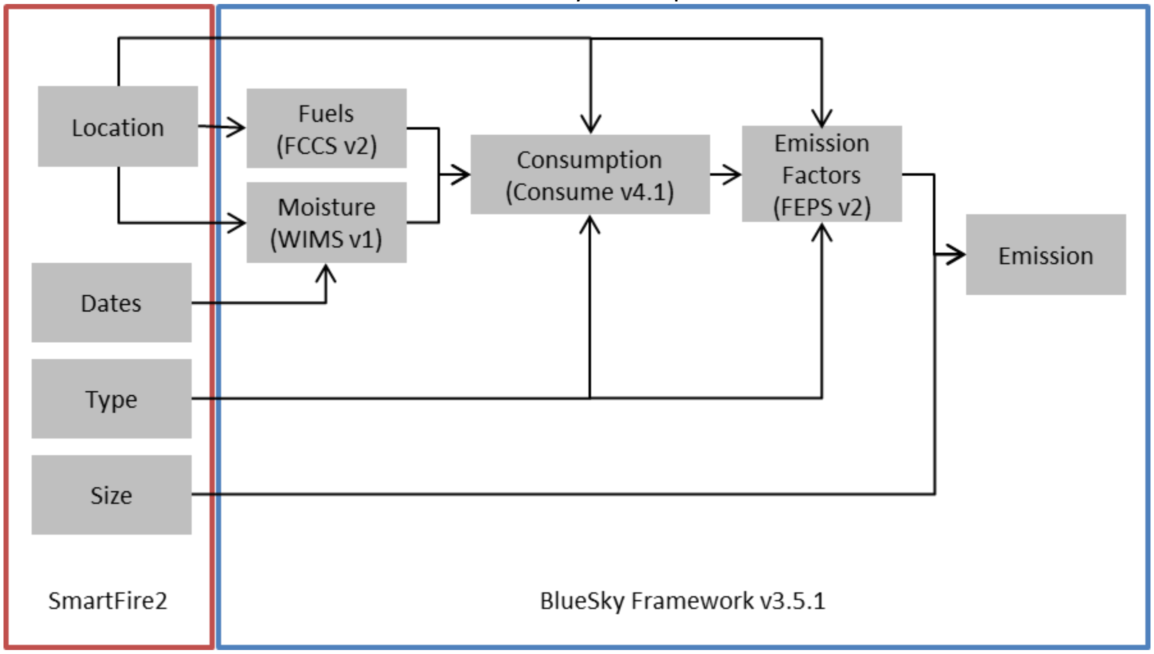


Table 7-3: Model chain for the Hawaii and Puerto Rico portion of the 2014 national wildland fire emissions inventory development

Data Type	Model Used	Version Information
Fire activity data	SmartFire2	Version 2.0, Build 42022
Fuel loading	FINN v1	As implemented in BlueSky Framework 3.5.1, revision 47693
Fuel consumption	FINN v1	
Emissions	FINN v1	

The Fire Emissions Production Simulator (FEPS) in the Bluesky Framework generates all the CAP emission factors for WLFs used in the NEI. However, for the 2014 NEI, the FEPS module has been updated to calculate emissions of HAPs and to calculate the smoldering and flaming components of emissions. In addition, the module was modified to compute emissions using regionalized HAP emission factors developed for this effort, which reflect differences in fire emissions in different parts of the country. The reader is referred to the FEPS module of the Bluesky model for CAP emission factors (see FEPS link listed above). The HAP emission factors used in this work came from Urbanski, 2015 [ref 5]. These emission factors were regionalized and handled differently by wild and prescribed fire. Table 7-4 outlines the regionalization scheme used while Table 7-5 and Table 7-6 show the HAP EFs employed in this work separately for wild and prescribed fires. Note the differences, in bold in Table 7-4, for wildfires and prescribed burning region assignments for Alaska and Wisconsin.

Table 7-4: Emission factor regions used to assign HAP emission factors for the 2014v1 NWLFEI

Region	Wildfires	Prescribed burning
Region 1	AZ, CA, IA, IL, IN, KS, MO, NM, NV, OH, OK, TX	AZ, CA, IA, IL, IN, KS, MO, NM, NV, OH, OK, TX
Region 2	**AK**, AL, AR, CT, DC, DE, FL, GA, HI, KY, LA, MA, MD, ME, MI, MN, MS, NC, NH, NJ, NY, PA, PR, RI, SC, TN, VA, VI, VT, **WI**, WV	AL, AR, CT, DC, DE, FL, GA, HI, KY, LA, MA, MD, ME, MI, MN, MS, NC, NH, NJ, NY, PA, PR, RI, SC, TN, VA, VI, VT, WV

Region	Wildfires	Prescribed burning
Region 3	CO, ID, MT, ND, NE, OR, SD, UT, WA, WY	**AK**, CO, ID, MT, ND, NE, OR, SD, UT, WA, **WI**, WY

Table 7-5: Prescribed fire HAP emission factors (lb/ton fuel consumed) for the 2014 NEI

HAP	Flaming			Smoldering		
	Region 1	**Region 2**	**Region 3**	**Region 1**	**Region 2**	**Region 3**
1,3-Butadiene (HAP 106990)	0.272326792	0.516619944	0.362434922	0.272326792	0.516619944	0.362434922
Acetaldehyde (HAP 75070)	1.678013616	1.283540248	2.240688827	1.678013616	1.283540248	2.240688827
Acetonitrile (HAP 75058)	0.322386864	0.064076892	0.43051662	0.322386864	0.064076892	0.43051662
Acrolein (HAP 107028)	0.512615138	0.646776131	0.684821786	0.512615138	0.646776131	0.684821786
Acrylic Acid (HAP 79107)	0.070084101	0.058069684	0.094112936	0.070084101	0.058069684	0.094112936
Anthracene (HAP 120127)	0.005	0.005	0.005	0.005	0.005	0.005
Benz(a)anthracene (HAP 56553)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Benzene (HAP 71432)	0.450540649	0.566680016	0.600720865	0.450540649	0.566680016	0.600720865
Benzo(a)fluoranthene (HAP 203338)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzo(a)pyrene (HAP 50328)	0.00148	0.00148	0.00148	0.00148	0.00148	0.00148
Benzo(c)phenanthrene (HAP 195197)	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039
Benzo(e)pyrene (HAP 192972)	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266
Benzo(ghi)perylene (HAP 191242)	0.00508	0.00508	0.00508	0.00508	0.00508	0.00508
Benzo(k)fluoranthene (HAP 207089)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzofluoranthenes (HAP 56832736)	0.00514	0.00514	0.00514	0.00514	0.00514	0.00514
Carbonyl Sulfide (HAP 463581)	0.000534	0.000534	0.000534	0.000534	0.000534	0.000534
Chrysene (HAP 218019)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Fluoranthene (HAP 206440)	0.00673	0.00673	0.00673	0.00673	0.00673	0.00673
Formaldehyde (HAP 50000)	2.515018022	3.366039247	4.475370445	2.515018022	3.366039247	4.475370445
Indeno(1,2,3-cd)pyrene (HAP 193395)	0.00341	0.00341	0.00341	0.00341	0.00341	0.00341
m,p-Xylenes (HAP 1330207)	0.216259511	0.160192231	0.288346015	0.216259511	0.160192231	0.288346015
Methanol (HAP 67561)	2.306768122	1.974369243	5.036043252	2.306768122	1.974369243	5.036043252
Methyl Chloride (HAP 74873)	0.128325	0.128325	0.128325	0.128325	0.128325	0.128325
Methylanthracene (HAP 26914181)	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823
Methylbenzopyrenes (HAP 65357699)	0.00296	0.00296	0.00296	0.00296	0.00296	0.00296
Methylchrysene (HAP 41637905)	0.0079	0.0079	0.0079	0.0079	0.0079	0.0079
Methylpyrene, fluoranthene (HAP 2381217)	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905
n-Hexane (HAP 110543)	0.048057669	0.024028835	0.064076892	0.048057669	0.024028835	0.064076892
Naphthalene (HAP 91203)	0.486583901	0.398478174	0.650780937	0.486583901	0.398478174	0.650780937
o-Xylene (HAP 95476)	0.07609131	0.050060072	0.100120144	0.07609131	0.050060072	0.100120144

HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
Perylene (HAP 198550)	0.000856	0.000856	0.000856	0.000856	0.000856	0.000856
Phenanthrene (HAP 85018)	0.005	0.005	0.005	0.005	0.005	0.005
Pyrene (HAP 129000)	0.00929	0.00929	0.00929	0.00929	0.00929	0.00929
Styrene (HAP 100425)	0.10412495	0.080096115	0.138165799	0.10412495	0.080096115	0.138165799
Toluene (HAP 108883)	0.344413296	0.398478174	0.45855026	0.344413296	0.398478174	0.45855026

Table 7-6: Wild fire HAP emission factors (lbs/ton fuel consumed) for the 2014 NEI

HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
1,3-Butadiene (HAP 106990)	0.272326792	0.140168202	0.362434922	0.272326792	0.140168202	0.362434922
Acetaldehyde (HAP 75070)	1.678013616	1.908289948	2.240688827	1.678013616	1.908289948	2.240688827
Acetonitrile (HAP 75058)	0.322386864	0.600720865	0.43051662	0.322386864	0.600720865	0.43051662
Acrolein (HAP 107028)	0.512615138	0.582699239	0.684821786	0.512615138	0.582699239	0.684821786
Acrylic Acid (HAP 79107)	0.070084101	0.080096115	0.094112936	0.070084101	0.080096115	0.094112936
Anthracene (HAP 120127)	0.005	0.005	0.005	0.005	0.005	0.005
benz(a)anthracene (HAP 56553)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Benzene (HAP 71432)	0.450540649	1.101321586	0.600720865	0.450540649	1.101321586	0.600720865
Benzo(a)fluoranthene (HAP 203338)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzo(a)pyrene (HAP 50328)	0.00148	0.00148	0.00148	0.00148	0.00148	0.00148
Benzo(c)phenanthrene (HAP 195197)	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039
Benzo(e)pyrene (HAP 192972)	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266
Benzo(ghi)perylene (HAP 191242)	0.00508	0.00508	0.00508	0.00508	0.00508	0.00508
Benzo(k)fluoranthene (HAP 207089)	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Benzofluoranthenes (HAP 56832736)	0.00514	0.00514	0.00514	0.00514	0.00514	0.00514
Carbonyl Sulfide (HAP 463581)	0.000534	0.000534	0.000534	0.000534	0.000534	0.000534
Chrysene (HAP 218019)	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
Fluoranthene (HAP 206440)	0.00673	0.00673	0.00673	0.00673	0.00673	0.00673
Formaldehyde (HAP 50000)	2.515018022	3.954745695	4.475370445	2.515018022	3.954745695	4.475370445
Indeno(1,2,3-cd)pyrene (HAP 193395)	0.00341	0.00341	0.00341	0.00341	0.00341	0.00341
m,p-Xylenes (HAP 1330207)	0.216259511	0.120144173	0.288346015	0.216259511	0.120144173	0.288346015
Methanol (HAP 67561)	2.306768122	2.613135763	5.036043252	2.306768122	2.613135763	5.036043252
Methyl Chloride (HAP 74873)	0.128325	0.128325	0.128325	0.128325	0.128325	0.128325
Methylanthracene (HAP 26914181)	0.00823	0.00823	0.00823	0.00823	0.00823	0.00823
Methylbenzopyrenes (HAP 65357699)	0.00296	0.00296	0.00296	0.00296	0.00296	0.00296
Methylchrysene (HAP 41637905)	0.0079	0.0079	0.0079	0.0079	0.0079	0.0079

HAP	Flaming			Smoldering		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
Methylpyrene,-fluoranthene (HAP 2381217)	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905
n-Hexane (HAP 110543)	0.048057669	0.054064878	0.064076892	0.048057669	0.054064878	0.064076892
Naphthalene (HAP 91203)	0.486583901	0.554665599	0.650780937	0.486583901	0.554665599	0.650780937
o-Xylene (HAP 95476)	0.07609131	0.054064878	0.100120144	0.07609131	0.054064878	0.100120144
Perylene (HAP 198550)	0.000856	0.000856	0.000856	0.000856	0.000856	0.000856
Phenanthrene (HAP 85018)	0.005	0.005	0.005	0.005	0.005	0.005
Pyrene (HAP 129000)	0.00929	0.00929	0.00929	0.00929	0.00929	0.00929
Styrene (HAP 100425)	0.10412495	0.11814177	0.138165799	0.10412495	0.11814177	0.138165799
Toluene (HAP 108883)	0.344413296	0.480576692	0.45855026	0.344413296	0.480576692	0.45855026

The FINN module (not BlueSky) was used for Hawaii and Puerto Rico, since FCCS data were not available for these regions, and FINN is capable of calculating emissions globally. FINN uses satellite-derived land cover data, estimated fuel loadings, and emission factors to model smoke emissions.

However, the FINN module does not compute emissions for VOCs or HAPs. Estimates of emissions of these species for Hawaii and Puerto Rico were based on the CO_2 outputs from FINN. The average ratios of VOCs and HAPs to CO_2 for wildland fires in grassland/herbaceous land cover, which is most similar to the vegetation type that burned in Hawaii and Puerto Rico, were calculated for the contiguous United States and applied to the CO_2 emissions of Hawaii and Puerto Rico fires to estimate VOC and HAP emissions.

7.4.5 Dataset post-processing

Daily fire emission estimates from BlueSky Framework were post-processed to address known issues and prepare data for final use [ref 6]. Post-processing included adjustment of the calculated duff consumption for certain fires, removal of agriculture and pile burns, speciation of $PM_{2.5}$ emissions, and final formatting.

The FEPS emission estimates for the contiguous United States and Alaska were corrected to address a known issue with emission estimates for prescribed fires in areas with large duff depths [ref 6]. To address overestimation of duff consumption in these fires, a scaling factor was calculated and applied to each fire to reduce phase-specific consumption and emissions. This adjustment was applied as follows:

1. New duff consumption of each prescribed burn was recalculated by setting a “cap” value for the duff consumption. For burns in western states (all states west of Texas, plus the Dakotas), the duff consumption cap was set to 20 tons per acre. For eastern states, the duff consumption cap was set to 5 tons per acre. These caps were developed in consultation with USFS and U.S. DOI experts. For each fire, the exceedance in duff consumption was calculated by subtracting capped duff consumption from the original duff consumption.
2. The new total consumption of each prescribed burn was calculated by removing the exceedance in duff consumption from the original total consumption.
3. The scaling factor for each prescribed burn was calculated as the ratio of the new total consumption over the original total consumption.
4. Finally, the burn-specific scaling factor was applied to phase-specific consumption (flaming, smoldering, and residual) and daily emissions of all pollutants to compute new fuel consumption and emissions.

Emissions from agricultural and pile burns are not accounted for in the 2014 NEI. Any fires that were identified as agricultural or pile burns in the modeling output were removed from the WLF NEI.

The 2014 NEI includes speciated components of $PM_{2.5}$ for the first time. $PM_{2.5}$ components were calculated as a fraction of total $PM_{2.5}$ by multiplying emissions by the speciation factors provided by EPA based on EPA's modeling platforms and SPECIATE 4.0. Table 7-7 provides the speciation factors used for the 2014 NEI.

Table 7-7: $PM_{2.5}$ speciation factors used to calculate $PM_{2.5}$ components for wildfires and prescribed fires

Pollutant	Wildfires	Prescribed burning
EC	0.09490	0.10930
OC	0.46180	0.50190
SO_4	0.01260	0.00330
NO_3	0.00132	0.01070
Other	0.42938	0.37480

Some updates to the outputs were made at the request of data providers, based on comments on the draft WLF EPA inventory. Four wildfires in the state of Delaware, representing all calculated wildfire activity for the state, were removed because it was known that no wildfires had occurred in 2014. The names of some fires in Michigan were also updated.

7.5 Development of the NEI

As stated previously, only Georgia and Washington submitted emissions for this data category. For all the other states, the emissions developed as outlined above by EPA methods were the basis for the inventory. In Washington's case, their data was accepted as submitted and no additions were made with EPA data. Appropriate HAP EFs were provided as shown in Table 7-5 and Table 7-6 that enabled them to compute the same HAPs that EPA estimates. In Georgia's case, because their initial HAP submission violated some QA checks on total HAPs having to be less than bulk VOC, we provided HAP:VOC fractions according to EPA estimates for their State. Georgia used these ratios and their VOC estimates to compute HAP emissions. Otherwise, as with Washington, Georgia's data was accepted as submitted, and no additions were made with EPA data. No HAP augmentation was necessary for either state. Both states submitted PM2.5 species according to the fractions shown in Table 7-7.

Georgia's methods were very similar to EPA's methods. Georgia provided the following documentation on their methods:

> Georgia Environmental Protection Division (EPD) has developed 2014 Georgia wildland fire emission inventory using the same fuel consumption and emission factors as was used to develop 2011 Georgia wildland fire emission inventory, which has been included as part of NEI 2011. Such fuel consumption and emission factors are developed as part of the Southeastern Modeling, Analysis, and Planning (SEMAP) fire emission inventory project and were considered as the best knowledge from fire and forest managers in the Southeast. Burned area [estimates] are based on 2014 burning records obtained from Georgia Forestry Commission and three military bases, as well as burning records of wildland fires on federal lands. No satellite fire detection data were used in Georgia EPD estimates. To fulfill the requirement of separating emission by flaming and smoldering combustion phases for NEI 2014, Georgia EPD ran CONSUME to generate separate emissions by flaming, smoldering and residual smoldering and calculated emission fractions by

combustion phases assuming that flaming and smoldering in CONSUME corresponds to flaming, and residual smoldering in CONSUME corresponds to smoldering. This assumption is made because the emissions during flaming and smoldering often coexist.

Washington provided the following reasons for having to estimate their own emissions after reviewing EPA's draft estimates in v1 of the WLF inventory:

Version 1 of the 2014 Fire NEI for Washington State included many sources of information: NASF, FWS, FACTS, NFPORS, ICS, GeoMAC, HMS, and FETS. The data based on HMS assumes size and fire type, so all fire locations in the NEI v1 (Rx, WF, and AG) based solely on HMS were spatiotemporally cross-checked with state databases of agricultural and prescribed pile burning. Spatiotemporally cross-checking fire databases (using GIS and satellite imagery) showed that many fire types were incorrect. There were 197 fire locations classified as agricultural burns (because they were marked as pasture/grassland in the CDL) that we re-classified as wildfire (e.g. parts of the Carlton Complex WF and Mills Canyon WF). There were 15 fire locations classified as agricultural burns (because they were marked as pasture/grassland in the CDL) that we re-classified as prescribed burns (e.g. in the Umatilla National Forest). The remaining agricultural burns in the NEI v1 were corrected for size and crop-type as able, combined with our state agricultural burn permit databases, and then submitted to EPA for NEI v2 (nonpoint). Note that many agricultural burns in Washington State are pile burns, but that the nonpoint submission rules assume all agricultural burns are "whole field set on fire". So, agricultural pile burns had to be submitted with fictional "acres burned" activity data. The Rx pile burns detected by HMS that were misclassified as broadcast burns in NEI v1 were corrected and combined with the other Rx pile burns in our state databases (same as pile burn data in FETS). All Rx pile burns were submitted as nonpoint data to EPA for NEI v2.

After the fire types were corrected and pile burns were accounted for, there were some updates to fuel loading for WF and Rx broadcast burns. Fuel loading in the FCCS map used by BlueSky is inaccurate for several fuel types, so they were updated with more realistic fuel loading and BlueSky was rerun for the affected fires.

- FCCS #0 ("urban" aka unknown fuel) had 1 inch of duff added
- FCCS #235 (Idaho Fescue – Bluebunch Wheatgrass Grassland) had 1 inch of duff added
    - FCCS #41 (Idaho Fescue – Bluebunch Wheatgrass Grassland) and #315 (Interior alpine forb grassland) were replaced with FCCS #235 with 1 inch of duff added
- FCCS #56 (Sagebrush Shrubland) had 1 inch of duff added
    - FCCS #60 (Sagebrush Shrubland – Sparse), #308 (Low sagebrush shrubland), and #311 (Salt-desert shrubland) were replaced with FCCS #56 with 1 inch of duff added
- FCCS #57 (Wheatgrass - Cheatgrass grassland) had 1 inch of duff added
- All fire locations with FCCS #900 (water) were changed to the nearest non-water fuel type.

All "events" data submitted by Washington State used the same emission factors and splitting of flaming/smoldering emissions that were used by EPA.

While Alaska accepted our methods and emission estimates, they had these specific comments for documentation:

1. ADEC uses specific fuel load factor for 80% by area or 20 biggest fires and used load factor is very likely different from fuel load factor EPA uses. The fuel load factors (canopy EPA) are provided to ADEC by

AICC in LANDFIRE files and site specific. For example, 3 biggest fires in 2014 had the following fuel factors tons/acre:

100 Mile	32.919961
Funny River	49.816033
OK RX	21.84224

2. ADEC assumes 100% of fuel load consumed.
3. ADEC uses adjusted to Alaska vegetation types, should not lead to a big discrepancy as at least 80% area factors are site specific see 1 above.
4. EPA uses fuel moisture in % from nearest WIMS and ADEC uses the following moisture gradation vwet, moist, mod, dry, vdry depending on month and location (FEPS Moisture regime curve).
5. ADEC uses simplified approach in smoldering emission calculations and we are interested in total emissions and EPA is interested in hourly emissions (likely for modeling purposes) and in total.

Similarly, NC accepted our emission estimates, but wanted these comments included in the documentation for the 2014v2 NEI:

> SmartFire Data Reconciliation Process: Our understanding is that a prescribed fire could be merged with a wildfire when they overlap in space and time (e.g., within 1 km apart on the same day) even when the fires come from the same data sources (i.e., State2014_NC). For these cases, the fire with the largest acreage is selected and classified as a wildfire. Going forward, it will be most helpful if the methodology could be changed to keep the fires separate so that wildfire acreage is not overestimated and prescribed fire acreage underestimated in the inventory. As I mentioned on the phone, it is important to be able to keep track of the type of each fire since they are treated differently under the regional haze rule (and exceptional events rule as well).
>
> Data Source Codes: If the methodology cannot be changed as noted previously, it will be helpful to provide a data source code to identify when a prescribed fire is merged with a wildfire when they overlap in space and time. This would be very helpful for understanding when the state submitted data are modified by the system.

7.6 Quality assurance

Quality assurance steps were implemented at each step of processing of the 2014 NEI to ensure the integrity of the product. In general, quality control involved review of data sets to ensure that data did not contain errors and reflected the most accurate available information. Quality control was performed on input fire information data sets, SF2 daily fire location output, and BlueSky Framework emissions estimates.

7.6.1 Input Fire Information Data Sets

Input data set quality control is described in the data preparation section above. In general, the following steps were followed.

- Reviewed input data sets to identify data gaps.
- Identified fire incidents that appeared to be double-counted in individual data sets and removed duplicate records.
- Examined fires with long durations or conflicts between date fields such as start date and report date to identify fires that may have erroneous dates, and made necessary corrections.

- Reviewed fire locations to ensure that they fell within the United States. Obvious errors in data entry such as the reversal of latitude and longitude were corrected where possible.
- Reviewed large and small fires in each data set for validity.
- Modified distant fires (in different states) with the same names to ensure that the events were not associated.

7.6.2 Daily Fire Locations from SmartFire2

Quality assurance actions applied to daily fire locations from SmartFire2 included:

- Checked the location, fire type, duration, underlying fire activity input data, final shape, and final size for large fire events (i.e., area burned >20,000 acres) to ensure that the results were reasonable.
- Checked large fire events by state and by name, removed duplicate events, and renamed fires as needed.
- Reviewed large fire events with multiple data sources to ensure that SmartFire2 reconciliation rankings were correct and produced sensible results.
- Identified and removed fire event duplicates incorrectly created by the SmartFire2 reconciliation process.
- Checked fire events with large differences between the calculated fire area and the geometric fire area. Since the shape and area are calculated separately in SmartFire2, a large discrepancy can indicate errors in reconciliation. For the 2014 NWLFEI, no errors of this sort were identified.

7.6.3 Emissions Estimates

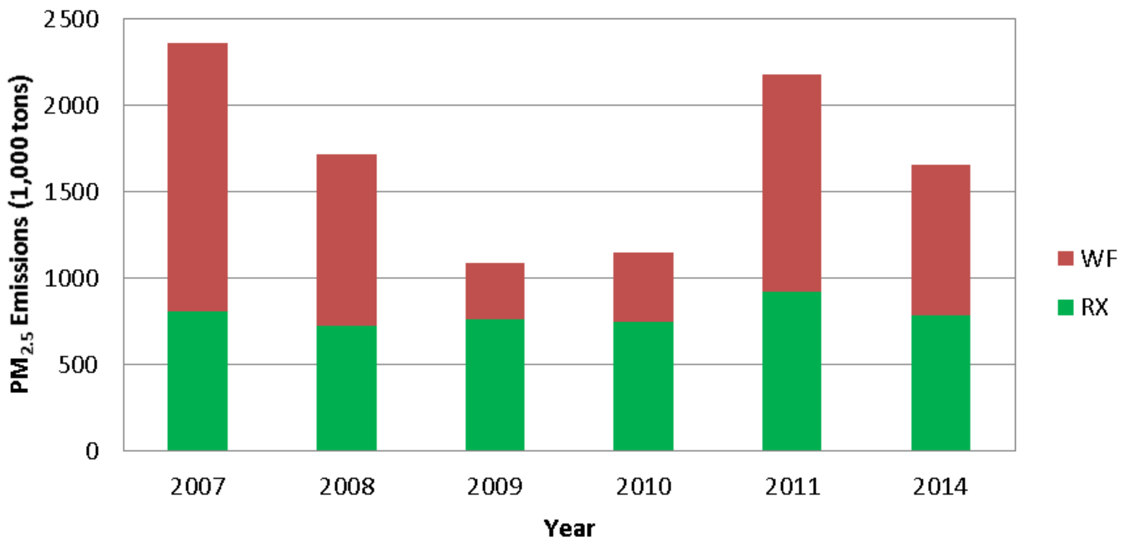
Quality assurance actions applied to resulting emissions estimates included:

- Checked the location of all final fires and emission estimates. Fires falling outside of the United States were removed. Some fires near the border were retained if fuel information was available in that location.
- Identified fire records that were incorrectly associated and adjusted fire event size and emissions proportionally.
- Removed any fires in Alaska that had only HMS as a source.
- Produced and reviewed summary tables and plots of the 2014 fire inventory data.
- Compared acres burned by state to National Interagency Fire Center data as well as the 2015 National Prescribed Fire Use Survey Report (of 2014 data) to ensure the summary values were within reasonable range.

7.6.4 Additional quality assurance on final results

WLF emissions developed using the methods described above were compared to EPA's 2011 estimates, since the models used are similar. The spatial (and temporal) patterns seen in the data correspond to what was expected in 2014, and how the domains changed from 2011 –In general, 2014 was a "better" fire year than 2011 as fewer acres were burned (about 30% less), so the emissions are expected to be lower in 2014 compared to 2011. The trends graphic in Figure 7-4 shows how the 2014 PM2.5 estimates compare to other years (using similar methods). These trends represent only the lower 48 states.

Figure 7-4: $PM_{2.5}$ WLF emissions trends from 2007-2014 using SF2 (for the lower 48 states)



In comparing the 2014 estimates to previous years, the following points of QA that were made should also be noted:

- 2011 emissions are much lower than 2014. However, it is within the range of the previous 5 inventories. The average wildland fire $PM_{2.5}$ emissions for 2007-2010 and 2011 is 1.66 million tons, while 2014 total emission is 1.47 million tons (excluding Alaska, Hawaii, and Puerto Rico).
- The major difference between 2014 and previous years is in wildfires because prescribed burn emissions stay relatively consistent over the years, averaging 792 thousand tons for previous years vs. 770 thousand tons for 2014 (excluding Alaska, Hawaii, and Puerto Rico). Wildfire activity is driven by the state of the climate, which varies greatly from year to year and from region to region, as well as by other factors such as fuel accumulation, human activity, lightning storm, etc. Many of the checks made on these parameters match what would be expected to happen to WLF emissions in 2014 in that domain.
- Examples of this type of QA include: 2014 was one of the wettest years for AK, which explains the decrease in wildfire activity in Alaska. The opposite was seen in California where it had suffered a few consecutive years of drought and experienced greater wildfire activity in 2014 than in 2011. Yet another example is 2011 was the driest year on record for Texas so it made sense that Texas had higher emissions in 2011 than in 2014.

Georgia and Washington were the only states to submit emissions data. A comparison of the data between the Georgia-submitted emissions and SF2-generated emissions for Georgia showed a very good match for wildfires, but a marginal match for prescribed fires. Due to that concern and some concerns that Georgia had on the spatial extent of emissions estimate on a county basis for Georgia in SF2 and on VOC emissions being too high with EPA methods, they submitted their own emissions in 2014. Similarly, in comparing EPA-generated emission estimates with WA's estimates, they decided they needed to submit emissions for the reasons outlined earlier as part of the comments they sent to EPA. In moving forward, another vital part of QA is to better understand state-submitted comments even though they accepted our emission estimates for the 2014 NEI.

7.7 Summary of results

In the 2014 NEI estimates, wildland fires burned about 15.2 million acres in the United States and emitted almost 1.7 million tons of $PM_{2.5}$. Of this area, about 4.2 million acres (24%) were burned by wildfires and 10.9 million acres (76%) by prescribed fires. Wildfire $PM_{2.5}$ emissions account for 53% and prescribed burns account for 47% of the total emissions in this emissions inventory. Table 7-8 summarizes acres burned and $PM_{2.5}$ emissions by state, fire type, and combustion phase. Additional details can be found in the STI documentation referenced below. Note that the GA and WA numbers listed below are from the S/L/T submission they made to this data category.

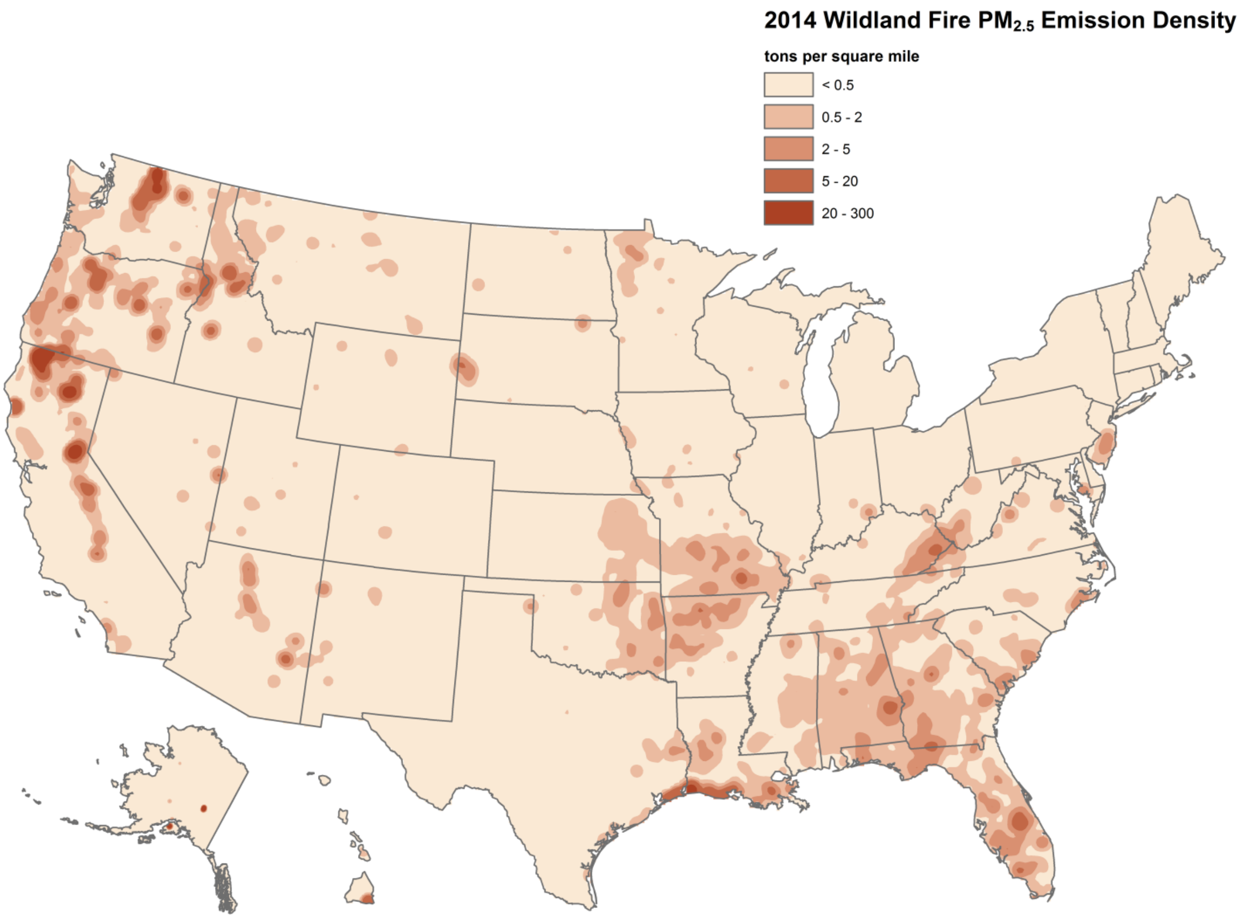
Table 7-8: Summary of NEI acres burned and $PM_{2.5}$ emissions by state, fire type, and combustion phase

State	Area (Acres)			$PM_{2.5}$ (Tons)						
	Total	Wildfire	Prescribed Fire	Total $PM_{2.5}$ Emissions	Wildfire			Prescribed Fire		
					Subtotal	Flaming	Smoldering	Sub total	Flaming	Smoldering
Alabama	1,140,870	74,433	1,066,437	69,117	9,001	2,882	6,119	60,116	20,528	39,588
Alaska	294,644	290,177	4,467	173,411	172,420	141,490	30,929	991	717	274
Arizona	367,897	249,873	118,023	26,939	20,557	10,525	10,032	6,381	4,279	2,102
Arkansas	449,046	21,713	427,333	48,493	4,112	2,400	1,712	44,380	26,567	17,814
California	788,143	635,494	152,649	295,438	271,220	203,701	67,519	24,218	16,483	7,735
Colorado	88,950	33,803	55,147	6,312	805	359	446	5,507	3,686	1,821
Connecticut	606	118	488	68	15	6	9	53	14	39
Delaware	3,013	0	3,013	160	0	0	0	160	57	104
Florida	1,802,824	110,910	1,691,914	97,306	6,377	1,949	4,428	90,929	29,297	61,631
Georgia (S/L/T)	1,380,782	23,176	1,357,606	56,281	1,142	1,032	110	55,141	48,319	6,821
Hawaii	56,920	0	56,920	11,150	0	0	0	11,150	0	11,150
Idaho	374,339	229,963	144,375	54,357	35,133	23,186	11,948	19,224	13,524	5,700
Illinois	139,138	2,816	136,322	9,901	303	153	150	9,598	4,505	5,092
Indiana	55,577	1,190	54,387	5,306	141	69	72	5,165	2,949	2,216
Iowa	212,266	12,761	199,506	12,396	987	432	555	11,409	4,521	6,888
Kansas	490,050	124,687	365,363	24,405	6,843	2,254	4,589	17,562	5,244	12,318
Kentucky	113,246	48,999	64,247	30,106	22,464	13,888	8,576	7,642	3,978	3,664
Louisiana	711,525	44,039	667,486	86,691	26,711	24,764	1,947	59,980	43,931	16,049
Maine	3,038	216	2,822	477	53	39	14	424	305	119
Maryland	19,076	3,168	15,909	2,836	1,487	1,334	153	1,349	986	363
Massachusetts	2,858	1,284	1,575	284	133	47	86	152	89	63
Michigan	33,478	3,287	30,191	2,710	331	147	184	2,379	1,342	1,036
Minnesota	297,587	4,934	292,653	22,630	850	473	376	21,780	12,150	9,630
Mississippi	562,702	41,745	520,956	26,913	3,284	1,123	2,161	23,629	8,921	14,708
Missouri	501,719	31,394	470,324	63,143	7,057	4,748	2,309	56,086	36,992	19,094
Montana	226,966	35,729	191,237	27,392	6,008	4,951	1,057	21,384	15,494	5,890
Nebraska	160,720	23,796	136,924	7,530	1,135	476	658	6,395	2,599	3,796
Nevada	100,586	85,116	15,470	9,466	8,672	5,180	3,492	794	562	232
New Hamp.	447	79	369	56	16	8	8	40	17	22
New Jersey	32,359	8,953	23,406	7,327	3,966	3,286	680	3,361	2,728	633

State	Area (Acres)			PM2.5 (Tons)						
	Total	Wildfire	Prescribed Fire	Total $PM_{2.5}$ Emissions	Wildfire			Prescribed Fire		
					Subtotal	Flaming	Smoldering	Sub total	Flaming	Smoldering
New Mexico	142,832	56,547	86,285	9,005	5,676	3,531	2,145	3,329	2,035	1,295
New York	9,788	2,945	6,843	1,207	464	255	209	743	443	299
N. Carolina	153,600	25,053	128,547	13,881	3,008	1,898	1,110	10,872	6,750	4,123
N. Dakota	135,184	1,383	133,802	9,870	87	35	52	9,783	5,085	4,699
Ohio	27,726	4,003	23,723	3,511	1,378	802	575	2,133	1,164	969
Oklahoma	541,760	163,871	377,888	41,022	14,244	5,607	8,637	26,778	13,047	13,731
Oregon	1,311,203	1,005,701	305,501	135,085	94,823	63,336	31,487	40,262	30,512	9,750
Pennsylvania	21,382	5,384	15,998	3,338	1,499	888	611	1,839	1,169	669
Puerto Rico	21,593	193	21,400	576	2	0	2	574	0	574
Rhode Island	246	24	222	16	5	3	3	11	3	7
S. Carolina	401,805	14,722	387,083	22,180	1,664	540	1,124	20,516	8,519	11,997
S. Dakota	96,903	15,262	81,642	15,265	2,049	1,325	724	13,216	9,026	4,190
Tennessee	127,020	22,836	104,184	16,576	5,592	2,492	3,100	10,984	4,492	6,492
Texas	804,389	159,399	644,990	50,670	22,768	17,540	5,228	27,902	11,637	16,265
Utah	118,434	48,240	70,194	6,486	2,591	1,295	1,296	3,896	2,238	1,658
Vermont	1,345	163	1,181	112	27	11	16	85	52	33
Virginia	117,354	16,774	100,580	16,682	5,395	2,957	2,439	11,287	6,248	5,038
Washington (S/L/T)	637,056	513,889	123,157	119,126	104,950	39,225	65,724	14,176	4,403	9,772
West Virginia	47,657	15,397	32,259	12,676	7,103	4,372	2,731	5,573	3,721	1,851
Wisconsin	69,246	2,868	66,378	4,314	196	72	124	4,118	2,005	2,113
Wyoming	62,704	15,763	46,941	6,863	1,502	1,072	430	5,361	3,999	1,361
Grand Total	**15,177,838**	**4,239,624**	**10,938,214**	**1,658,014**	**875,230**	**622,039**	**253,191**	**782,784**	**402,698**	**380,086**

In the 2014 NEI, the table above and Figure 7-5 (Puerto Rico data is not shown) shows that the bulk of emissions originate from two regions: The West and the Southeast. This spatial distribution of emissions is consistent with previous national fire inventories. Spring and winter emissions are mostly from the southeastern states, where prescribed burning is a common land management practice in spring, and, to a lesser extent, at the end of the year. Summer/fall emissions occur primarily in the West, particularly in California, Oregon, Washington, and Idaho.

Figure 7-5: 2014 NEI wildland fire $PM_{2.5}$ emission density



7.8 Improvements in the 2014 NEI v1 compared to the 2011 NEI

The methods used to develop the 2014 WLF NEI included several changes and improvements over methods used in the previous NEI cycle (2011).

7.8.1 Fire activity data

The 2014 NEI incorporates a total of 30 S/L/T and national fire activity data sets (23 S/L/T and 7 national data sets), similar to the breadth of the data used for the 2011 NEI (31 total, 24 S/L/T and 7 national data sets). However, in the 2014 effort, S/L/T data submitters were asked to respond to a data questionnaire by providing data completeness information for their data. We could use this self-assessed information from 21 S/L/T agencies to better understand their data and make an informed decision about how their fire activity data should be supplemented with national data sets (Table 7-2). Instead of applying the national fire activity data sets universally to all S/L/T entities, as was done for the 2011 NEI, data supplement policies were directly guided by S/L/T input to ensure the final fire activity data best represented S/L/T knowledge.

In addition, the FACTS dataset for 2014 was obtained in polygon format, an improvement over the point data used in the 2011 NEI. Polygons provide more accurate fire location, shape, and size information. Also, NFPORS fire activity data for the DOI was added to the national data sets that helped improve the fire emissions estimates.

7.8.2 SmartFire2 processing

During SF2 processing of fire activity data, two software issues were identified and workarounds to address these issues were made. First, some daily fire records were lost when daily exports were created (saving one export file per day). In previous years, daily export was the preferable export method due to system performance concerns. However, upgraded computing resources for SF2 allowed for exporting all of 2014's data at once, eliminating the inadvertent loss of some daily fire records.

Second, it was found that some input fires were incorrectly associated with two separate fire events, resulting in double counting of acres burned. This issue was caused by reconciling fire events twice in an effort to prevent double counting caused by another reason, namely, fires that intersect within spatial and temporal uncertainties are not associated and reconciled. The issue was resolved by developing a standalone R script to sift through SF2 inputs and outputs to identify the duplicated fire events. The duplicates were removed from subsequent processing. Refer to the STI documentation [ref 1] for further details.

7.8.3 Emission factors

As previously mentioned, updated HAP emission factors were provided by EPA based on a peer reviewed publication [ref 5]. The new emission factors were region- and fire-type-specific and were based on the latest research carried out by the Missoula Fire Sciences Laboratory at the USFS. A complete list of these emission factors was provided earlier and is available in the literature.

7.9 Future areas of improvement

7.9.1 More accurate fuel loading

A limitation of the BlueSky Framework v3.5.1 is that it only accepts fire location point input. For a given fire location, the fuel bed assignment is based upon the point location. When a fire is small, the fuel bed at a single point may be representative of the primary fuels burned. However, for large fires, basing the fuel loading within the fire perimeter on a single point could result in significant over- or under-estimation of fuels consumed, possibly biasing the emission estimate. We recommend exploring options to provide more accurate fuel loading information for large fires. Potentially, this could be achieved by modifying SF2 and BlueSky Framework so that a given fire could be represented by multiple points or a polygon instead of one single point.

7.9.2 Pile burn emissions

During the data collection process, we received pile burn data sets from 13 S/L/T data submitters. In addition, pile burn data were included in the data we acquired from two national sources, NFPORS and FACTS. To reasonably estimate emissions from pile burns, two pieces of pile information are required: count and fuel loading of the piles (fuel loading may also be estimated from pile volume and composition). There was only one state whose pile burn data provided the minimum amount of information. In cases where the minimum required information is not provided, estimating pile burn emissions requires the use of default values for either pile count or pile fuel loading. However, due to time and budgetary constraints, it was not feasible to request missing information from data submitters or develop default values collectively with both the research community and S/L/T agencies for the 2014 NEI v1.

Most of the pile burn data sets for 2014 included hundreds or thousands of records, suggesting that the emissions from pile burning practices are not trivial. For future EI development, we recommend that methods for estimating pile burn emissions be considered. Inclusion of pile burns in future EIs would provide a more complete estimation of emissions from wildland fires. To do this with more confidence requires default information to be available on pile burns in the Bluesky framework.

7.9.3 SmartFire2 improvements

Two issues were identified with SF2 during the development of the 2014 NEI. First, daily fire records may be lost when daily exports are created. Second, input fires can be incorrectly associated into two separate fire events, resulting in double counting of acres burned. Although corrective steps were adopted to mitigate the impacts the issues had on the data, these bugs should be addressed before future SF2 development.

7.9.4 VOC emission factors

At least two states, Georgia and Alaska, have noted that the emission factor for VOC used for the NEI is too high as default from Bluesky. It is recommended that a literature review of VOC emission factors be conducted and that the most up-to-date value(s) be utilized for future emission inventory development.

7.9.5 Centralized fire information database

Beginning with the 2011 version, the NEI has incorporated S/L/T fire activity data sets. The collection, review, cleaning, and standardization of a few dozen data sets require a significant amount of time and labor. This process could be streamlined if there were a centralized fire activity database where S/L/T agencies could store all their fire activity data. All the data would be stored in one place and in one universal format. Such a centralized database would not only save both time and money for future emission inventory development, but also potentially serve other purposes such as prescribed burn planning, permitting, and tracking. Loading and quality assuring these data in EIS could be investigated for future NEIs.

7.10 References for wildland fires

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8 Biogenics – Vegetation and Soil

Biogenic emissions are emissions that come from natural sources. They need to be accounted for in photochemical grid models, as most types are widespread and ubiquitous contributors to background air chemistry. In the NEI, only the emissions from vegetation and soils are included, but other relevant sources include volcanic emissions, lightning oxides of nitrogen (NOx), and sea salt.

Biogenic emissions from vegetation and soils are computed using a model that utilizes spatial information on vegetation, land use and environmental conditions of temperature and solar radiation. The model inputs are typically horizontally allocated (gridded) data, and the outputs are gridded biogenic emissions, which can then be speciated and utilized as input to photochemical grid models.

8.1 Sector description

In the 2014 NEI, biogenic emissions are included in the nonpoint data category, in the EIS sector "Biogenics – Vegetation and Soil." Table 8-1 lists the two source classification codes (SCCs) used in the 2014 NEI that comprise this sector. The level 1 and 2 SCC description for both SCCs is "Natural Sources; Biogenic" and the full Tier 3 description for both SCCs is "Natural Resources; Biogenic; Vegetation". These two SCCs have distinct pollutants: SCC 2701220000 has only NO_X emissions, and SCC 2701200000 has emissions for carbon monoxide (CO), volatile organic compounds (VOC) and three VOC hazardous air pollutants (HAPs): formaldehyde, acetaldehyde and methanol.

Table 8-1: SCCs for Biogenics – Vegetation and Soil

SCC	SCC Level 3	SCC Level 4
2701200000	Vegetation	Total
2701220000	Vegetation/Agriculture	Total

The biogenic emissions for the 2014 National Emissions Inventory (NEI) were computed based on 2014 meteorology data from the Weather Research and Forecasting (WRF) model version 3.8 (WRFv3.8) and using the Biogenic Emission Inventory System, version 3.61 (BEIS3.61) model within the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system. The BEIS3.61 model creates gridded, hourly, model-species emissions from vegetation and soils. The 12-kilometer gridded hourly data are summed to monthly and annual level, and are mapped from 12-kilometer grid cells to counties using a standard mapping file. BEIS produces biogenic emissions for a modeling domain which includes the contiguous 48 states in the U.S., parts of Mexico, and Canada. The NEI uses the biogenic emissions from counties from the contiguous 48 states and Washington, DC.

The model-species are those associated with the carbon bond 2005 chemical mechanism (CB05). The NEI pollutants produced are: CO, VOC, NOx, methanol, formaldehyde and acetaldehyde. VOC is the sum of all biogenic species except CO, nitrogen oxide (NO), and sesquiterpene (SESQ). Mapping of BEIS pollutants to NEI pollutants is as follows:

- NO maps to NO_X
- FORM maps to formaldehyde
- ALD2 maps to acetaldehyde
- MEOH maps to methanol
- VOC is the sum of all biogenic species except CO, NO, SESQ

BEIS3.61 has some important updates from BEIS 3.14. These include the incorporation of Version 4.1 of the Biogenic Emissions Land Use Database (BELD4) for the 2011v6.3 platform, and the incorporation of a canopy model to estimate leaf-level temperatures [ref 1]. BEIS3.61 includes a two-layer canopy model. Layer structure varies with light intensity and solar zenith angle. Both layers of the canopy model include estimates of sunlit and shaded leaf area based on solar zenith angle and light intensity, direct and diffuse solar radiation, and leaf temperature [ref 2].

The new algorithm requires additional meteorological inputs as compared to previous versions of BEIS, and these meteorology inputs must be in a data file format that is output from the Meteorology-Chemistry Interface Processor (MCIP). MCIP is also used to convert WRF outputs to inputs for the Community Multi-scale Air Quality (CMAQ) model. The meteorology input data fields used by BEIS are shown in Table 8-2.

Table 8-2: Meteorological variables required by BEIS 3.61

Variable	Description
LAI	leaf-area index
PRSFC	surface pressure
Q2	mixing ratio at 2 m
RC	convective precipitation per met TSTEP
RGRND	solar rad reaching surface
RN	non-convective precipitation per met TSTEP
RSTOMI	inverse of bulk stomatal resistance
SLYTP	soil texture type by USDA category
SOIM1	volumetric soil moisture in top cm
SOIT1	soil temperature in top cm
TEMPG	skin temperature at ground
USTAR	cell averaged friction velocity
RADYNI	inverse of aerodynamic resistance
TEMP2	temperature at 2 m

BELD version 4.1 is based on an updated version of the U.S. Department of Agriculture (USDA) and U.S. Forest Service (USFS) Forest Inventory and Analysis (FIA) database. FIA reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. The FIA database version 5.1 includes recent updates of these data through the year 2014 (from 2001). Earlier versions of BELD used an older version of the FIA database that had included data only through the year 2012. Canopy coverage is based on the Landsat satellite National Land Cover Database (NLCD) product from 2011. The FIA includes approximately 250,000 representative plots of species fraction data that are within approximately 75 km of one another in areas identified as forest by the NLCD canopy coverage. The 2011 NLCD provides land cover information with a native data grid spacing of 30 meters. For land areas outside the conterminous United States, 500-meter grid spacing land cover data from the Moderate Resolution Imaging Spectroradiometer (MODIS) is used.

Other improvements to the BELDv4.1 data included the following:

- Used 30-meter NASA's Shuttle Radar Topography Mission (SRTM) elevation data which will more accurately define the elevation ranges of the vegetation species.
- Used the 2011 30-meter USDA Cropland Data Layer (CDL) data to improve the BELD4 agricultural categories.

- After 2014v1 of the NEI, additional quality assurance of the BELD4.1 resulted in minor corrections to the land use data in three states including Washington, Texas and Florida. These minor corrections were implemented in the 2014v2 NEI and represent about less than 1% reduction in biogenic emissions in these three states.

8.2 Sources of data overview and selection hierarchy

The only source of data for this sector is the EPA-estimated emissions from BEIS3.61. States are neither required nor encouraged to report biogenic emissions, and no state has done this. The name of the EPA dataset in the EIS is: 2014EPA_biogenics.

8.3 Spatial coverage and data sources for the sector

The spatial coverage of the biogenics emissions is governed by the 2011 Version 6 Air Emissions Modeling Platforms modeling domain which covers all counties in the lower 48 states.

8.4 References for biogenics

1. Pouliot, G. and J. Bash, 2015. Updates to Version 3.61 of the Biogenic Emission Inventory System (BEIS). Presented at Air and Waste Management Association conference, Raleigh, NC, 2015.

2. Bash, J.O., Baker, K.R., Beaver, M.R., Park, J.-H., Goldstein, A.H., 2016. Evaluation of improved land use and canopy representation in BEIS with biogenic VOC measurements in California.