Appendix A
2008 Base Year Annual
Carbon Monoxide (CO) Emissions Inventory
For St. Louis County and St. Louis City

Missouri Department of Natural Resources
Division of Environmental Quality
Air Pollution Control Program
Jefferson City, Missouri

Public Hearing
January 30, 2014

Project Number: 1971-CO-5

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1.0 Introduction

1.1 Purpose

This document meets the nonattainment plan provisions under the Clean Air Act Section 172 (c)(3):

> *"Such plan provisions shall include a comprehensive, accurate, current inventory of actual emissions from all sources of the relevant pollutant or pollutants in such area, including such periodic revisions as the Administrator may determine necessary to assure that the requirements of this part are met."*

Missouri's limited maintenance plan for the 8-hour CO National Ambient Air Quality Standard (NAAQS) requires a base year emissions inventory for 2008. The inventory is comprehensive in its inclusion of multiple source categories (point, nonpoint or area, and mobile sources), it is accurate based on the quality assurance steps outlined in Section 4, contains current 2008 actual emissions for CO, and can be updated through the triennial National Emissions Inventory (NEI). Emissions are documented for both the statewide inventory and the St. Louis Nonclassifiable CO Maintenance Area.

1.2 Inventory Coverage

1.2.1 Geography

The inventory covers St. Louis County and the City of St. Louis. Several summaries of statewide Missouri totals are also included for reference. There are no inventory components provided by local or tribal agencies.

1.2.2 Emission Year

Emission year 2008 is the base year.

1.2.3 Pollutants

The only pollutant covered in the inventory is the criteria pollutant CO.

1.3 Contents of Report

This report documents the 2008 inventory in detail, from its creation, quality assurance, and final summaries. It also details the qualifications and limitations of the inventory. The document is arranged by purpose, emission summaries, documentation, quality assurance, and detailed appendices with lengthy emissions data tables and EPA provided category documentation.

1.4 Automated Systems Used

The 2008 emission inventory is maintained across multiple computing systems. Point source inventories are compiled from facility-supplied information in the Missouri Emissions Inventory System (MoEIS) database. Point sources are allowed to submit their inventory data via the MoEIS web interface or on hardcopy paper forms which are data entered to the electronic system. Nonpoint emissions are calculated using Microsoft® Excel spreadsheet and Access database tools. Mobile emissions are estimated using EPA's Motor Vehicle Emissions Simulator (MOVES), and the National Mobile Inventory Model (NMIM) which incorporates the NONROAD2008 model.

1.5 Inventory Exclusions

This 2008 inventory does not include biogenic or geogenic emissions. The inventory does not include the nonpoint categories for wildfire, prescribed, or agricultural burning, agricultural tilling, plus others described in section 3.2.2. This inventory does not include hazardous air pollutant (HAP) inventories as they are not relevant pollutants for the Carbon Monoxide Maintenance plan. The HAP inventory is documented in Missouri's 2008 National Emissions Inventory Documentation and is available on EPA's NEI page at http://www.epa.gov/ttn/chief/net/2008inventory.html. Point emissions data is summarized at the facility level in this document, though facility operational data and emission process data is collected and submitted to the NEI.

1.6 Guidance and Reference Documents

This document is completed with the following references:

- Emissions Inventory Guidance for Implementation of Ozone and Particulate matter National Ambient Air Quality Standards (NAAQS) and Regional Haze Regulations (August 2005, EPA-454/R-05-001, http://www.epa.gov/ttnchie1/eidocs/eiguid/index.html)
- Emission Inventory Improvement Plan (EIIP) (July 1997, http://www.epa.gov/ttn/chief/eiip/index.html)
- 2008 National Emissions Inventory Data version 1.5 and documentation (May 2011, http://www.epa.gov/ttn/chief/net/2008inventory.html)
- Air Emission Reporting Rule (Dec 2008, http://www.epa.gov/ttn/chief/aerr/)
- AP-42, Compilation of Air Pollutant Emission Factors (http://www.epa.gov/ttn/chief/ap42/index.html)
- MOVES Technical Guidance, Policy Memos, etc at (http://www.epa.gov/otaq/models/moves/index.htm)
- National Mobile Inventory Model (NMIM) (http://www.epa.gov/oms/nmim.htm)

1.7 List of Contacts

The emission inventory is compiled by Stacy Allen, Environmental Specialist IV and Emission Inventory/Data Management Unit Chief with the Missouri Department of Natural Resources. Specific contacts for other portions of the inventory are:

Point and Nonpoint Emissions: Stacy Allen, stacy.allen@dnr.mo.gov
Mobile (Onroad and Nonroad) Emissions: Nathan O'Neil, nathan.o'neil@dnr.mo.gov

2.0 Emissions Summary

2.1 Summary by County and Category

Table 1 Total 2008 CO Emissions for St. Louis City and St. Louis County

Area	Source Category	2008 CO Emissions (tons/year)
St. Louis County	Point Sources	4,995.09
St. Louis County	Area Sources	8,752.71
St. Louis County	On Road Mobile Sources	132,855.83
St. Louis County	Off Road Mobile Sources	76,069.44
St. Louis County	**subtotal**	**222,673.07**
St. Louis City	Point Sources	1,319.83
St. Louis City	Area Sources	3,086.57
St. Louis City	On Road Mobile Sources	34,576.81
St. Louis City	Off Road Mobile Sources	15,573.38
St. Louis City	**subtotal**	**54,556.59**
Total (St. Louis City and County)	Point Sources	6,314.92
Total (St. Louis City and County)	Area Sources	11,839.28
Total (St. Louis City and County)	On Road Mobile Sources	167,432.64
Total (St. Louis City and County)	Off Road Mobile Sources	91,642.82
Total (St. Louis City and County)	**Total**	**277,229.66**

3.0 Inventory Documentation

3.1 Point Source Emissions

3.1.1 Procedures and Methodologies

The point source inventory is based on information collected on Emissions Inventory Questionnaires (EIQs). Facilities with a construction or operating permit from the Air Pollution Control Program are required to submit an EIQ on an annual basis per 10 CSR 10-6.110. The EIQ details the amount of air pollution emitted and other operational data for the previous calendar year.

2008 point sources include those with Part 70 and Intermediate operating permits. The EIQ solicitation was mailed to facilities in January 2009. The due date for 2008 reporting was June 1, 2009, and all point source reports were received and included in this document summary.

3.1.2 Emission Inventory Questionnaire (EIQ)

All point source emissions data for the State of Missouri is contained in a database called the Missouri Emissions Inventory System (MoEIS). Emission reports may be submitted either directly via the MoEIS web interface, a user-friendly, online portal linked directly to the MoEIS database, or they may be submitted on the hardcopy EIQ forms. Hardcopy EIQ submittals are then data entered into the MoEIS database by EI unit staff members. As a result, the MoEIS database is updated yearly with the most current emissions data for the State of Missouri.

Hardcopy EIQ forms are described in Table 2. All hardcopy forms have an electronic counterpart in the MoEIS web interface system. In general, forms beginning with number one (1) provide general information about a facility, forms beginning with a two (2) provide the detailed annual emission calculations, including activity or throughput, emission factors, emissions, and operational characteristics. More information on EIQ forms and instructions and MoEIS is available at http://www.dnr.mo.gov/env/apcp/moeis/emissionsreporting.htm

Table 2 List of EIQ Forms

FORM NAME	FORM DESCRIPTION	FORM NUMBER
FORM 1.0 GENERAL PLANT INFORMATION	GENERAL PLANT INFORMATION, PLANT-WIDE EMISSIONS TOTALS, SIGNATURE SECTION CERTIFYING SUBMITTED INFORMATION IS ACCURATE AND COMPLETE	780-1431
FORM 1.1 PROCESS FLOW DIAGRAM	DIAGRAM IDENTIFYING AND LINKING ALL EMISSION UNITS, PROCESSES, AIR POLLUTION CONTROL DEVICES, AND EMISSION RELEASE POINTS FOR A FACILITY. SUBMIT ONLY IF THERE HAVE BEEN CHANGES.	780-1619

FORM NAME	FORM DESCRIPTION	FORM NUMBER
FORM 1.2 SUMMARY OF EMISSION UNITS AND RELATED PROCESSES	LIST OF ALL EMISSION UNITS AND ASSOCIATED PROCESSES AND THE STATUS OF EACH (ACTIVE, INSIGNIFICANT, DISMANTLED)	780-1620
FORM 2.0 EMISSION UNIT INFORMATION	MAIN EMISSIONS REPORTING FORM; SEPARATE FORM 2.0 REQUIRED FOR EACH PROCESS FOR WHICH EMISSIONS ARE BEING REPORTED (I.E., FORM 2.0 NOT REQUIRED FOR EMISSIONS BELOW REPORTING THRESHOLDS)	780-1621
FORM 2.0C CONTROL DEVICE INFORMATION	CONTROL DEVICE INFORMATION WHEN THERE IS A CONTROL DEVICE OPERATIVE AT AN EMISSION UNIT; SEPARATE FORM 2.0C REQUIRED FOR EACH CONTROL DEVICE	780-1434
FORM 2.0K CHARCOAL KILN INFORMATION	DETAILS THE OPERATIONS AND CHARACTERISTICS OF CHARCOAL KILNS	780-1530
FORM 2.0L LANDFILL INFORMATION	FORM FOR REPORTING EMISSIONS FROM LANDFILLS	780-1583
FORM 2.0P PORTABLE EQUIPMENT INFORMATION	DETAILS THE LOCATIONS AND OPERATIONS FOR PORTABLE EQUIPMENT OPERATIONS INCLUDING QUARRIES, ASPHALT PLANTS, AND CONCRETE BATCH PLANTS	780-1433
FORM 2.0S STACK/VENT INFORMATION	STACK INFORMATION FOR EMISSION UNITS WHERE EMISSIONS FROM A PROCESS ENTER THE AMBIENT AIR THROUGH ONE OR MORE STACKS/VENTS	780-1435
FORM 2.0Z OZONE SEASON INFORMATION FORM	CALCULATION OF OZONE SEASON DAY EMISSIONS OF VOC, NO_X, OR CO; REQUIRED FROM FACILITIES LOCATED IN ST. LOUIS, ST. CHARLES, FRANKLIN AND JEFFERSON COUNTIES AND ST. LOUIS CITY WITH 10 TONS OR MORE OF VOC, NO_X OR CO ANNUAL EMISSIONS.	780-1452
FORM 2.1 FUEL COMBUSTION WORKSHEET	INFORMATION RELATED TO COMBUSTION EQUIPMENT, FUEL USAGE, AND THE CALCULATIONS ASSOCIATED WITH COMBUSTION PROCESSES	780-1436
FORM 2.2 INCINERATOR WORKSHEET	INFORMATION RELATED TO THE INCINERATOR, WASTE MATERIAL(S) INCINERATED, AND THE ANNUAL WASTE MATERIAL THROUGHPUT	780-1438
FORM 2.3 VOC PROCESS MASS-BALANCE WORKSHEET	CALCULATES A VOC MASS BALANCE EMISSION FACTOR	780-1440

FORM NAME	FORM DESCRIPTION	FORM NUMBER
FORM 2.4 VOLATILE ORGANIC LIQUID LOADING WORKSHEET	CALCULATES AN EMISSION FACTOR FOR PETROLEUM LIQUID LOADING INTO TANK TRUCKS, RAIL CARS, AND BARGES BASED ON AP-42	780-1625
FORM 2.5L GENERAL LIQUID STORAGE TANK INFORMATION	INFORMATION ABOUT STORAGE TANKS	780-1444
FORM 2.7 HAUL ROAD FUGITIVE EMISSIONS WORKSHEET	CALCULATES AN EMISSION FACTOR FOR UNPAVED HAUL ROADS BASED ON AP-42 FORMULA	780-1445
FORM 2.8 STORAGE PILE WORKSHEET	CALCULATES EMISSION FACTORS FOR ACTIVITY AND WIND EROSION FROM STORAGE PILES BASED ON AP-42 FORMULAS	780-1446
FORM 2.9 STACK TEST/CONTINUOUS EMISSION MONITORING WORKSHEET	DOCUMENTATION FOR EMISSION FACTORS DERIVED FROM STACK TESTS OR CEM DEVICES	780-1447
FORM 2.T HAZARDOUS AIR POLLUTANT WORKSHEET	INFORMATION ON HAP CHEMICALS EMITTED AT THE PROCESS LEVEL; SEPARATES INDIVIDUAL HAPS FROM THOSE INCLUDED IN VOC/PM EMISSIONS	780-1448
FORM 3.0 EMISSION FEE CALCULATION	SUMMARY TABLE SHOWING EMISSIONS FROM ALL PROCESSES	780-1509
FORM 3.0CK EMISSION FEE CALCULATION FOR CHARCOAL KILNS	SUMMARY TABLE SHOWING EMISSIONS FROM CHARCOAL KILN OPERATIONS	780-1508
DRY CLEANER – NON-CHLORINATED AND PETROLEUM BASED SOLVENTS	EMISSIONS CALCULATIONS FOR DRY CLEANERS USING NON-CHLORINATED SOLVENT AND WITH COMBINED DRYER CAPACITY OF 84 POUNDS OR MORE	780-1954
FORM 4.0 FINANCIAL COST ESTIMATE	ESTIMATE THE COST OF COMPLYING WITH AIR POLLUTION REGULATION	780-1622

Point source EIQ data received via hard copy forms is data entered to the MoEIS emissions database by emission inventory staff. During this step, process-level emissions and operational information are checked for consistency between the hardcopy forms and database calculations, and inconsistencies are flagged for review. Problems include, but are not limited to:

- Incorrect Source Classification Codes (SCCs)
- Emission unit numbering changes

Calculation errors
Missing or incomplete records
Transposition errors

If no errors are found during data entry, and the emissions reported on the hardcopy full EIQ match what is calculated by the MoEIS database, then the emission report is considered complete and data entered.

EIQs with inconsistencies are moved from emission inventory data entry staff to a member of the technical review team. The technical review team will address the problems encountered during data entry by identifying the specific issue(s) and possible causes and contacting the facility to resolve those issues. Other issues may also be addressed during the review, including the appropriate use of emission estimation methods, documentation of source data, and consistency with permit emission calculations. Supplemental EIQ information may be collected by staff via telephone or email contact with the facility in question. Information collected in this manner will be recorded on the EIQ for reference, tracking and QA auditing. If the facility is requested to submit follow up verification or additional information in writing, a statement pertaining to this request will also be recorded on the EIQ. The information recorded will include the date of the call or contact, staff person's name, contact person's name, and written documentation of the call.

After the submission deadline of June 1 has passed, a list of unsubmitted EIQs is generated and sent to the compliance and enforcement section of the Air Pollution Control Program. With all emissions data contained in the MoEIS database, further quality assurance steps are completed as described in Section 4.

3.1.3 List of Facilities and Emissions

There are 139 facilities in the point source inventory for the Missouri counties of the St. Louis nonattainment area. Their primary economic activity described by their North American Industry Classification System (NAICS) code is listed in Table 3 for St. Louis City and St. Louis County. The emissions of each facility in tons per year are listed in Table 4.

Table 3 St. Louis County and City 2008 Point Sources by NAICS

Primary Economic Activity Description	St. Louis County	St. Louis City
Adhesive Manufacturing	1	1
Administration of Air and Water Resource and Solid Waste Management Programs		1
Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing		
Aircraft Manufacturing	1	
All Other Basic Organic Chemical Manufacturing		1
All Other Miscellaneous Textile Product Mills		1
All Other Rubber Product Manufacturing		1
Asphalt Paving Mixture and Block Manufacturing	6	1
Automobile Manufacturing	2	
Biological Product (except Diagnostic) Manufacturing		1
Breweries		1
Carburetor, Piston, Piston Ring, and Valve Manufacturing	1	

Primary Economic Activity Description	St. Louis County	St. Louis City
Cement Manufacturing		
Coated and Laminated Packaging Paper Manufacturing	1	
Coffee and Tea Manufacturing		1
Colleges, Universities, and Professional Schools	1	1
Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	1	
Commercial and Institutional Building Construction		1
Commercial Bakeries		1
Commercial Flexographic Printing	1	
Commercial Lithographic Printing	2	2
Crushed and Broken Limestone Mining and Quarrying	3	
Dry Pasta Manufacturing		1
Electronic Coil, Transformer, and Other Inductor Manufacturing		
Electroplating, Plating, Polishing, Anodizing, and Coloring		
Fabric Coating Mills		
Fabricated Structural Metal Manufacturing		
Farm Supplies Merchant Wholesalers		1
Flour Milling		2
Folding Paperboard Box Manufacturing		
Fossil Fuel Electric Power Generation	1	1
General Medical and Surgical Hospitals	5	3
General Warehousing and Storage		1
Glass Container Manufacturing		
Glass Product Manufacturing Made of Purchased Glass	1	
Grain and Field Bean Merchant Wholesalers		1
Heating Equipment (except Warm Air Furnaces) Manufacturing		1
Industrial Sand Mining	1	
Industrial Valve Manufacturing		
Inorganic Dye and Pigment Manufacturing	1	1
Institutional Furniture Manufacturing	1	
Iron and Steel Pipe and Tube Manufacturing from Purchased Steel		
Laminated Aluminum Foil Manufacturing for Flexible Packaging Uses		1
Leather and Hide Tanning and Finishing		1
Machine Tool (Metal Cutting Types) Manufacturing	1	
Manifold Business Forms Printing		1
Metal Can Manufacturing		
Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers		2
Motor Vehicle Body Manufacturing		
Motor Vehicle Seating and Interior Trim Manufacturing		
National Security		1
Natural Gas Distribution		1
Natural Gas Liquid Extraction		2
Newspaper Publishers	1	1
Offices of Physicians (except Mental Health Specialists)		1
Other Aircraft Parts and Auxiliary Equipment Manufacturing	1	
Other Metal Container Manufacturing	1	

Primary Economic Activity Description	**St. Louis County**	**St. Louis City**
Other Metal Valve and Pipe Fitting Manufacturing		1
Paint and Coating Manufacturing		3
Pesticide and Other Agricultural Chemical Manufacturing	1	
Petrochemical Manufacturing	1	2
Petroleum Bulk Stations and Terminals	1	
Pharmaceutical Preparation Manufacturing	3	
Plastics Material and Resin Manufacturing	1	
Polystyrene Foam Product Manufacturing	1	
Primary Smelting and Refining of Nonferrous Metal (except Copper and Aluminum)		
Railroad Rolling Stock Manufacturing		
Research and Development in the Physical, Engineering, and Life Sciences	1	
Rubber and Plastics Hoses and Belting Manufacturing	1	
Secondary Smelting and Alloying of Aluminum		1
Semiconductor and Related Device Manufacturing		
Sewage Treatment Facilities	3	
Ship Building and Repairing		
Sign Manufacturing		
Soap and Other Detergent Manufacturing		2
Solid Waste Landfill	4	
Spice and Extract Manufacturing		1
Steel Foundries (except Investment)		
Steel Investment Foundries		
Toy and Hobby Goods and Supplies Merchant Wholesalers		1
Truck Trailer Manufacturing	1	
Unlaminated Plastics Profile Shape Manufacturing		
Wired Telecommunications Carriers		1
Total Number of Facilities	52	49

Table 4 St. Louis County and City 2008 Point Source CO Emissions by Facility (tons per year)

Area	Site ID	Facility Name	CO Emissions
St. Louis County	0002	Chrysler Assembly Plant 1-Fenton	21.86
St. Louis County	0010	Amerenue-Meramec Plant	3,811.99
St. Louis County	0017	Fred Weber Inc-North Stone	
St. Louis County	0019	Fred Weber Inc-South Stone	
St. Louis County	0020	Monsanto World Headquarters-Lindbergh Blvd	10.33
St. Louis County	0021	U S Silica Company-Pacific	3.51
St. Louis County	0025	Dana Corporation-Perfect Circle Division	0.87
St. Louis County	0032	Pharmacia-Chesterfield Village	14.82
St. Louis County	0035	Rockwood Pigments Na Inc-E Hoffmeister	8.27
St. Louis County	0042	Washington University-Millbrook Blvd	18.42
St. Louis County	0057	St Louis Post-Dispatch-Dunlap Ind Dr	0.16
St. Louis County	0064	Sunnen Products Company-Maplewood	1.01
St. Louis County	0065	St Louis Airport Authority-Lambert International Blvd	9.38
St. Louis County	0111	Simpson Construction Materials Llc-West Lake Quarry & Material Co	15.71
St. Louis County	0141	Energy Petroleum Company-Kienlen	
St. Louis County	0208	Printpack Inc-Hazelwood Plant	3.45
St. Louis County	0217	Metropolitan St Louis Sewer District-Lemay Waste Water Treatment Plant	321.07
St. Louis County	0226	Nesco Container Corp-Fenton	1.07
St. Louis County	0230	McDonnell Douglas Corp /Boeing Company-Lindbergh Plant	20.96
St. Louis County	0231	Chrysler Corp-North Plant	65.23
St. Louis County	0238	St Louis Lithographing Company-Heege Avenue	
St. Louis County	0242	Multiplex Display Fixture-Fenton	0.49
St. Louis County	0275	Bussen Quarries Inc-Bussen Road	
St. Louis County	0276	Ruprecht Quarry-Paule Rd	
St. Louis County	0281	BFI Missouri Pass Landfill-Maryland Heights	30.58
St. Louis County	0282	Color Art Inc-Crestwood	1.01
St. Louis County	0308	Fred Weber Inc Sanitary Landfill-St Louis County	130.13
St. Louis County	0310	Onyx Oak Ridge Landfill Inc-(West County)	44.89
St. Louis County	0312	Bridgeton Landfill Authority-Bridgeton	244.28
St. Louis County	0315	Flex-O-Lite Inc-Fenton	-
St. Louis County	0317	Pro-Tect Mfg Inc-Ferguson Ave	
St. Louis County	0318	St Marys Health Center-Richmond Heights	6.74
St. Louis County	0327	Camie-Campbell Inc-Watson Industrial Park	
St. Louis County	1012	Belt Service Corp-Earth City	0.47
St. Louis County	1015	Kv Pharmaceutical Company-Brentwood	-
St. Louis County	1029	Depaul Health Center-Bridgeton	6.05
St. Louis County	1047	Kv Pharmaceutical Company-Schuetz Rd	1.22
St. Louis County	1052	Veterans Admin Medical Center-Jefferson Barracks Drive	-
St. Louis County	1097	Reichhold Chemicals Inc-Valley Park	4.40
St. Louis County	1101	St Luke'S Hospital-Woods Mill Road	5.24

Area	Site ID	Facility Name	CO Emissions
St. Louis County	1156	St Joseph Hospital-Kirkwood	2.99
St. Louis County	1192	Pan-Glo St Louis-Trenton Avenue	
St. Louis County	1204	Whitmire Microgen Research Laboratory-Kirkwood	
St. Louis County	1205	Metropolitan St Louis Sewer District-Mo River Wasterwater Treatment Plant	7.10
St. Louis County	1210	Metropolitan St Louis Sewer District-Coldwater Creek Sewage Treatment Plant	50.69
St. Louis County	1226	Simpson Construction Materials Llc-Valley Park	20.28
St. Louis County	1248	Fred Weber Inc-South Asphalt	24.49
St. Louis County	1249	Fred Weber Inc-North Asphalt H & B	37.15
St. Louis County	1250	Fred Weber Inc-North Asphalt B & G	37.42
St. Louis County	1489	Gkn Aerospace Services Inc-Berkeley	11.36
St. Louis County	1520	F & S Real Eastate Inc-St Louis	
St. Louis County	1538	KV PHARMACEUTICAL-BRIDGETON	-
St. Louis County Total			**4,995.09**
St. Louis City	0003	Anheuser-Busch Inc-St Louis	145.98
St. Louis City	0017	Mallinckrodt Inc	77.49
St. Louis City	0027	Precoat Metals	5.10
St. Louis City	0031	ADM Gromark River Systems-St Louis	0.00
St. Louis City	0038	Trigen-St Louis Energy Corp-Ashley Street Station	46.27
St. Louis City	0040	Washington Univ Medical School-Boiler Plant	28.23
St. Louis City	0047	Fred Weber Inc-Asphalt Plant	9.56
St. Louis City	0053	Metropolitan St Louis Sewer District-Bissel Plant	552.29
St. Louis City	0057	Procter & Gamble-Procter & Gamble	9.89
St. Louis City	0063	Dial Corp-Dial Corp	8.39
St. Louis City	0066	Elementis Specialties Inc	6.78
St. Louis City	0070	Astaris Llc-Carondelet Plant	27.07
St. Louis City	0096	P D George Co (The)	3.73
St. Louis City	0097	U S Paint Div Of Grow Group-U S Paint Div Of Grow Group	
St. Louis City	0118	Alumax Foils Inc-Alcoa Foil Products/Alumax Foils Inc	14.02
St. Louis City	0159	ADM/TPC Milling Co-Pillsbury Company	-
St. Louis City	0161	Poly One Corporation-St Louis	
St. Louis City	0162	Marquette Tool & Die	
St. Louis City	0175	St Louis Metallizing-St Louis	0.08
St. Louis City	0179	Italgrani Elevator	3.22
St. Louis City	0200	St Alexius Hospital-St Louis	0.33
St. Louis City	0204	Bjc Health System-Pavillion	1.51
St. Louis City	0269	Sensient Colors Inc-Baldwin Plant	2.41
St. Louis City	0391	Hermann Oak Leather Co	-
St. Louis City	0468	Lange-Stegmann Co	0.00
St. Louis City	0697	Sigma - Aldrich Co	3.14
St. Louis City	0808	Chemisphere Corporation-Chemisphere	
St. Louis City	0809	PQ Corporation (The)-St Louis	9.65

Area	Site ID	Facility Name	CO Emissions
St. Louis City	0938	Interstate Brands Corp-Interstate Brands Corp	1.27
St. Louis City	1055	Goodwin Printing Co -St Louis	
St. Louis City	1077	Mid-West Industrial Chemical	-
St. Louis City	1093	Brenntag Mid-South Inc	0.00
St. Louis City	1123	U S Ringbinder Corp-Loose Leaf Metals	
St. Louis City	1280	St Louis Post Dispatch	0.44
St. Louis City	1370	National Geospatial-Intelligence Agency	1.38
St. Louis City	1396	Sigma - Aldrich Co-Sigma Chemical Company	4.92
St. Louis City	1407	Southern Metal Processing	2.17
St. Louis City	1423	Ashland Distribution Company-St Louis Plant	
St. Louis City	1460	Allied Health Care Products	-
St. Louis City	1505	Energy Center (The)-St Louis Univ Health Sciences Center	9.43
St. Louis City	1519	Permacel St Louis Inc-Permacel St Louis Inc	2.30
St. Louis City	1556	Connector Castings	0.00
St. Louis City	1642	J S Alberici Construction	-
St. Louis City	2300	Superior Solvent & Chemical-St Louis	
St. Louis City	2378	Laclede Tower Associates Llc-Laclede Gas Building	320.75
St. Louis City	2433	New World Pasta- Marceau Facility-New World Pasta	4.59
St. Louis City	2545	Southwestern Bell Telephone Company	6.68
St. Louis City	2711	St Louis University-Facilities Svcs	9.70
St. Louis City	2833	WASHINGTON UNIVERSITY-HILLTOP CAMPUS	1.06
St. Louis City Total			**1,319.83**
St. Louis County and St. Louis City Combined			**6,314.92**

Table 5 Statewide Point Source Emissions by Category (tons per year)

Category Description	***Number of Facilities***	***CO Emissions***
Fossil Fuel Electric Power Generation	76	22,142
Primary Smelting and Refining of Nonferrous Metal (except Copper and Aluminum)	2	23
Cement Manufacturing	6	11,122
Steam and Air-Conditioning Supply	3	94
Petrochemical Manufacturing	2	121
Primary Aluminum Production	1	24,771
Pesticide and Other Agricultural Chemical Manufacturing	5	173
Lime Manufacturing	2	11,843
Pipeline Transportation of Natural Gas	10	1,350
Sewage Treatment Facilities	4	931
Nitrogenous Fertilizer Manufacturing	1	
Breweries	1	146
Secondary Smelting, Refining, and Alloying of Nonferrous Metal (except Copper and Aluminum)	1	13,391
Lead Ore and Zinc Ore Mining	2	0
Medicinal and Botanical Manufacturing	2	3
Automobile Manufacturing	2	159
Soybean Processing	4	34
Motor Vehicle Body Manufacturing	9	16
All Other Categories	435	5,959
Statewide Total	**568**	**92,278**

Table 6 Statewide Point Emissions by County (tons per year)

State County FIPS Code	County Name	CO Emissions
29001	Adair	0.05
29003	Andrew	8.66
29007	Audrain	237.83
29009	Barry	31.17
29011	Barton	125.64
29013	Bates	1.58
29017	Bollinger	161.20
29019	Boone	1,143.44
29021	Buchanan	220.11
29023	Butler	220.70
29025	Caldwell	
29027	Callaway	51.94
29029	Camden	1.61
29031	Cape Girardeau	8,724.64
29033	Carroll	4.10
29037	Cass	109.64
29039	Cedar	8.20
29041	Chariton	
29047	Clay	105.47
29049	Clinton	-
29051	Cole	112.87
29053	Cooper	75.60
29055	Crawford	
29061	Daviess	1.34
29063	DeKalb	3.86
29065	Dent	38.34
29069	Dunklin	32.55
29071	Franklin	2,496.24
29073	Gasconade	1.58
29075	Gentry	-
29077	Greene	1,828.54
29079	Grundy	3.69
29081	Harrison	19.60
29083	Henry	519.94
29087	Holt	7.54
29091	Howell	1,034.81
29093	Iron	13,390.58
29095	Jackson	4,257.40
29097	Jasper	980.35
29099	Jefferson	1,683.83
29101	Johnson	81.04
29105	Laclede	38.55
29107	Lafayette	7.84
29109	Lawrence	21.75
29111	Lewis	
29113	Lincoln	6.22
29115	Linn	0.04
29117	Livingston	1.38

State County FIPS Code	County Name	CO Emissions
29119	McDonald	52.65
29121	Macon	120.37
29123	Madison	194.01
29125	Maries	22.89
29127	Marion	150.36
29131	Miller	0.05
29133	Mississippi	0.92
29137	Monroe	0.04
29139	Montgomery	82.34
29143	New Madrid	25,872.19
29145	Newton	43.28
29147	Nodaway	380.16
29151	Osage	78.95
29155	Pemiscot	4.25
29157	Perry	5.39
29159	Pettis	418.53
29161	Phelps	23.80
29163	Pike	1,792.34
29165	Platte	652.80
29167	Polk	-
29169	Pulaski	9.45
29171	Putnam	0.01
29173	Ralls	84.78
29175	Randolph	4,493.43
29179	Reynolds	-
29183	St. Charles	900.69
29186	Ste. Genevieve	11,853.64
29187	St. Francois	45.81
29189	St. Louis	4,995.08
29195	Saline	114.08
29201	Scott	375.52
29203	Shannon	19.55
29205	Shelby	82.31
29207	Stoddard	118.32
29209	Stone	
29213	Taney	29.80
29215	Texas	17.62
29217	Vernon	31.19
29219	Warren	6.68
29221	Washington	4.55
29225	Webster	0.31
29229	Wright	39.63
29510	St. Louis city	1,319.86
Missouri Total		**92,239.10**

3.2 Nonpoint Source Emissions

3.2.1 Procedures and Methodologies

The nonpoint (also known as area) source categories with published methods of estimation are too numerous to calculate county-level inventories given current resources. The EPA, in conjunction with the Eastern Region Technical Advisory Committee (ERTAC), will complete inventory documentation and calculation for most nonpoint source categories using national defaults. Several categories are then improved with state-level information or with point-source subtraction.

Missouri prepared inventories for 18 categories that required point source subtraction or state-specific data. These categories are listed in the Missouri Category Summary section below. Documentation of the calculation methodology and data sources is included in Table . Categories that did not require point source subtraction that were calculated by EPA are listed in the EPA Category Summary section.

3.2.2 List of Source Categories and Emissions

Table 8 includes a list of all area source categories and the 2008 emissions from each category for St. Louis City and St. Louis County..

Table 7 Nonpoint 2008 Emission Records for St. Louis County and City (tons per year)

Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions
St. Louis County	2102001000	Stationary Source Fuel Combustion	Anthracite Coal	Industrial	Total: All Boiler Types	-
St. Louis County	2102002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Industrial	Total: All Boiler Types	302.17
St. Louis County	2102004000	Stationary Source Fuel Combustion	Distillate Oil	Industrial	Total: Boilers and IC Engines	1.44
St. Louis County	2102005000	Stationary Source Fuel Combustion	Residual Oil	Industrial	Total: All Boiler Types	0.41
St. Louis County	2102006000	Stationary Source Fuel Combustion	Natural Gas	Industrial	Total: Boilers and IC Engines	4.14
St. Louis County	2102007000	Stationary Source Fuel Combustion	Liquified Petroleum Gas (LPG)	Industrial	Total: All Boiler Types	-
St. Louis County	2102008000	Stationary Source Fuel Combustion	Wood	Industrial	Total: All Boiler Types	213.58
St. Louis County	2102011000	Stationary Source Fuel Combustion	Kerosene	Industrial	Total: All Boiler Types	-
St. Louis County	2103001000	Stationary Source Fuel Combustion	Anthracite Coal	Commercial/Institutional	Total: All Boiler Types	-
St. Louis County	2103002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Commercial/Institutional	Total: All Boiler Types	2.10
St. Louis County	2103004000	Stationary Source Fuel Combustion	Distillate Oil	Commercial/Institutional	Total: Boilers and IC Engines	0.02
St. Louis County	2103005000	Stationary Source Fuel Combustion	Residual Oil	Commercial/Institutional	Total: All Boiler Types	-
St. Louis County	2103006000	Stationary Source Fuel Combustion	Natural Gas	Commercial/Institutional	Total: Boilers and IC Engines	11.07
St. Louis County	2103007000	Stationary Source Fuel Combustion	Liquified Petroleum Gas (LPG)	Commercial/Institutional	Total: All Combustor Types	0.71
St. Louis County	2103008000	Stationary Source Fuel Combustion	Wood	Commercial/Institutional	Total: All Boiler Types	2.15
St. Louis County	2103011000	Stationary Source Fuel Combustion	Kerosene	Commercial/Institutional	Total: All Combustor Types	0.01
St. Louis County	2104002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Residential	Total: All Combustor Types	76.40
St. Louis County	2104004000	Stationary Source Fuel Combustion	Distillate Oil	Residential	Total: All Combustor Types	1.06
St. Louis County	2104006000	Stationary Source Fuel Combustion	Natural Gas	Residential	Total: All Combustor Types	504.76
St. Louis County	2104007000	Stationary Source Fuel Combustion	Liquified Petroleum Gas (LPG)	Residential	Total: All Combustor Types	4.50

Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions
St. Louis County	2104008100	Stationary Source Fuel Combustion	Wood	Residential	Fireplace: general	1,367.95
St. Louis County	2104008210	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; non-EPA certified	2,146.20
St. Louis County	2104008220	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; non-catalytic	375.81
St. Louis County	2104008230	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; catalytic	92.70
St. Louis County	2104008310	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, non-EPA certified	1,758.77
St. Louis County	2104008320	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, non-catalytic	344.06
St. Louis County	2104008330	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, catalytic	84.99
St. Louis County	2104008400	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: pellet-fired, general (freestanding or FP insert)	39.08
St. Louis County	2104008510	Stationary Source Fuel Combustion	Wood	Residential	Furnace: Indoor, cordwood-fired, non-EPA certified	413.58
St. Louis County	2104008610	Stationary Source Fuel Combustion	Wood	Residential	Hydronic heater: outdoor	761.67
St. Louis County	2104009000	Stationary Source Fuel Combustion	Firelog	Residential	Total: All Combustor Types	147.52
St. Louis County	2104011000	Stationary Source Fuel Combustion	Kerosene	Residential	Total: All Heater Types	0.56
St. Louis County	2302002100	Industrial Processes	Commercial Cooking - Charbroiling	Food and Kindred Products: SIC 20	Conveyorized Charbroiling	22.69
St. Louis County	2302002200	Industrial Processes	Commercial Cooking - Charbroiling	Food and Kindred Products: SIC 20	Under-fired Charbroiling	64.38
St. Louis County	2302003000	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Deep Fat Frying	-
St. Louis County	2302003100	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Flat Griddle Frying	8.22
St. Louis County	2302003200	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Clamshell Griddle Frying	-
St. Louis County Total						**8,752.71**
St. Louis City	2102001000	Stationary Source Fuel Combustion	Anthracite Coal	Industrial	Total: All Boiler Types	-
St. Louis City	2102002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Industrial	Total: All Boiler Types	180.54

Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions
St. Louis City	2102004000	Stationary Source Fuel Combustion	Distillate Oil	Industrial	Total: Boilers and IC Engines	0.86
St. Louis City	2102005000	Stationary Source Fuel Combustion	Residual Oil	Industrial	Total: All Boiler Types	0.25
St. Louis City	2102006000	Stationary Source Fuel Combustion	Natural Gas	Industrial	Total: Boilers and IC Engines	2.04
St. Louis City	2102007000	Stationary Source Fuel Combustion	Liquified Petroleum Gas (LPG)	Industrial	Total: All Boiler Types	-
St. Louis City	2102008000	Stationary Source Fuel Combustion	Wood	Industrial	Total: All Boiler Types	138.74
St. Louis City	2102011000	Stationary Source Fuel Combustion	Kerosene	Industrial	Total: All Boiler Types	-
St. Louis City	2103001000	Stationary Source Fuel Combustion	Anthracite Coal	Commercial/Institutional	Total: All Boiler Types	-
St. Louis City	2103002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Commercial/Institutional	Total: All Boiler Types	2.08
St. Louis City	2103004000	Stationary Source Fuel Combustion	Distillate Oil	Commercial/Institutional	Total: Boilers and IC Engines	0.02
St. Louis City	2103005000	Stationary Source Fuel Combustion	Residual Oil	Commercial/Institutional	Total: All Boiler Types	-
St. Louis City	2103006000	Stationary Source Fuel Combustion	Natural Gas	Commercial/Institutional	Total: Boilers and IC Engines	7.86
St. Louis City	2103007000	Stationary Source Fuel Combustion	Liquified Petroleum Gas (LPG)	Commercial/Institutional	Total: All Combustor Types	0.61
St. Louis City	2103008000	Stationary Source Fuel Combustion	Wood	Commercial/Institutional	Total: All Boiler Types	2.21
St. Louis City	2103011000	Stationary Source Fuel Combustion	Kerosene	Commercial/Institutional	Total: All Combustor Types	0.01
St. Louis City	2104002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Residential	Total: All Combustor Types	67.06
St. Louis City	2104004000	Stationary Source Fuel Combustion	Distillate Oil	Residential	Total: All Combustor Types	0.85
St. Louis City	2104006000	Stationary Source Fuel Combustion	Natural Gas	Residential	Total: All Combustor Types	178.48
St. Louis City	2104007000	Stationary Source Fuel Combustion	Liquified Petroleum Gas (LPG)	Residential	Total: All Combustor Types	2.32
St. Louis City	2104008100	Stationary Source Fuel Combustion	Wood	Residential	Fireplace: general	440.92
St. Louis City	2104008210	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; non-EPA certified	641.76

Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions
St. Louis City	2104008220	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; non-catalytic	137.55
St. Louis City	2104008230	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; catalytic	35.48
St. Louis City	2104008310	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, non-EPA certified	595.41
St. Louis City	2104008320	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, non-catalytic	116.06
St. Louis City	2104008330	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, catalytic	29.04
St. Louis City	2104008400	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: pellet-fired, general (freestanding or FP insert)	14.17
St. Louis City	2104008510	Stationary Source Fuel Combustion	Wood	Residential	Furnace: Indoor, cordwood-fired, non-EPA certified	141.36
St. Louis City	2104008610	Stationary Source Fuel Combustion	Wood	Residential	Hydronic heater: outdoor	260.87
St. Louis City	2104009000	Stationary Source Fuel Combustion	Firelog	Residential	Total: All Combustor Types	53.50
St. Louis City	2104011000	Stationary Source Fuel Combustion	Kerosene	Residential	Total: All Heater Types	0.45
St. Louis City	2302002100	Industrial Processes	Commercial Cooking - Charbroiling	Food and Kindred Products: SIC 20	Conveyorized Charbroiling	8.11
St. Louis City	2302002200	Industrial Processes	Commercial Cooking - Charbroiling	Food and Kindred Products: SIC 20	Under-fired Charbroiling	25.78
St. Louis City	2302003000	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Deep Fat Fying	-
St. Louis City	2302003100	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Flat Griddle Frying	2.16
St. Louis City	2302003200	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Clamshell Griddle Frying	-
St. Louis City Total						**3,086.57**
St. Louis Nonclassifiable Maintenance Area Total						**11,839.28**

Table 8 Nonpoint Category Overview of Methodology

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
21030* and 21020*	Industrial and Commercial Institutional Fuel Combustion	16	CAP	Yes	EPA/CENRAP Template including energy intensity per sector NAICS		Huntley 2009 [6]	2006 EIA's SEDS [1]	2006
2401005000	Automobile Refinishing	1	VOC and 5 HAPS	No	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401015000	Wood and Flat Stock (Factory Finished Wood)	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401020000	Wood Furniture	1	VOC only	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401025000	Metal Furniture	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2401030000	Paper Film Foil	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401040000	Metal Cans	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401045000	Metal Coil Only	1	VOC and 6 HAPs	No	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401050000	Metal Sheet Strip and Coil	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment, HAPs not included in template were created by MODNR		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2401055000	Machinery and Equipment	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401060000	Appliances	1	VOC and 6 HAPs	No	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401065000	Electronic and other special coatings	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401070000	Motor Vehicles	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment, HAPs not included in template were created by MODNR		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2401075000	Aircraft	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment, HAPs not included in template were created by MODNR		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401085000	Railroads	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2401080000	Marine Coatings	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment, HAPs not included in template were created by MODNR		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2401090000	Misc Manufacturing	1	VOC and 6 HAPs	Yes	EPA Template - emissions based on employment, HAPs not included in template were created by MODNR		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2415000000	Degreasing	1	VOC and 1 HAP	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2420000000	Dry Cleaning	1	VOC only	No	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006
2425000000	Graphic Arts	1	VOC and 5 HAPs	Yes	EPA Template - emissions based on employment		Solvent Documentation [4]	Employment from 2006 *County Business Patterns* [2]	2006

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2401001000	Architectural Coatings	1	VOC and 5 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008
2401008000	Traffic Paints	1	VOC and 4 HAPs	No		Template - emissions based on 2006 highway miles	Solvent Documentation [4]	2006 FHWA HPMS[5]	2006
2401100000	Industrial Maintenance Coatings	1	VOC and 6 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008
2401200000	Other Special Purpose Coatings	1	VOC and 6 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008
2460100000	Personal Care Products	1	VOC and 2 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2460200000	Cleaning Products: household	1	VOC and 2 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008
2460400000	Automotive Aftermarket	1	VOC and 2 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008
2460500000	Coatings and Related Products	1	VOC and 2 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008
2460600000	Adhesives and Sealants	1	VOC and 2 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008
2460800000	FIFRA Regulated Products	1	VOC and 2 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2460900000	Misc Products	1	VOC and 2 HAPs	No		Template - population based emissions	Solvent Documentation [4]	Population from US Census [3]	2008
2501050120	Bulk Terminal	1	VOC and 8 HAPs	Yes	EPA Template - point source emissions subtracted by NAICS and county		No emission factor, scaled up 1998 VOC emission from MACT analysis[8]	Scaled 1998 emissions by 2008 DOE [7]	2008
2501055120	Bulk Plants	1	VOC and 8 HAPs	Yes	EPA Template - point source emissions subtracted by NAICS and county		From Gas distribution MACT standards[8]	9% of total gasoline consumption from 2008 EIA Petroleum Navigator[10]	2008
2505040120	Petroleum Pipeline	1	VOC and 8 HAPs	No	EPA Template		No emission factor, scaled up 1998 VOC emission from MACT analysis[8]	Scaled 1998 emissions by 2008 DOE[7]	2008
2501060201	Gasoline Stage 1 Underground Storage Tanks	1	VOC and 8 HAPs	No	EPA Template		EIIP 2001 [9]	2008 NMIM county-level onroad and nonroad estimates	2008

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2505030120	Gasoline Stage 1 Trucks in Transit	1	VOC and 8 HAPs	No	EPA Template		EIIP 2001 [9]	2008 NMIM county-level onroad and nonroad estimates	2008
250106005*	Gasoline Service Station Loading (submerg, splash, and balanced fill)	3	VOC and 8 HAPs	No	EPA Template		AP-42 Section 5.2[11]	2008 NMIM county-level onroad and nonroad estimates	2008
2501060100	Gasoline Distribution: Stage II	1	VOC and 8 HAPs	No	EPA Template		AP-42 Section 5.2[11]	2008 NMIM county-level onroad and nonroad estimates	2008
21040*	Residential Fuel Combustion (multiple fuel types)	16	CAPs	No		EPA Templates and Residential Wood Combustion Tool[25]	AP-42	EIA[1]	2006
2280002*	Mobile Sources - Marine Vessels - port and underway emissions	2	CAP	No		2002 estimates adjusted for 2008 activity	EPA's Office of Transportation and Air Quality (OTAQ) CAP, SEPA HAP speciation[13]	Regional growth factor for vessel activity	2002 grown to 2008

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2294000000 and 2296000000	Paved and Unpaved Roads	2	PM10 FIL/PRI, PM25 FIL/PRI	No		AP-42 Equation with state or regional constants	AP-42 Section 13.2.2	2007 FHWA Highway Statistics[14]	2007
230200*	Commerical Cooking	5	CAP and HAP	No		Template - population based emissions	2002 emissions divided by population to create per captia factors	Population from US Census [3]	2008
23110*	Construction Dust (residential, industrial/commercial, roadway)	3	PM10 PRI, PM25 PRI	No		Residential activity by county used, allocate national roadway by employment	EPA documentation	Construction from Census[15] and highway construction FHWA[14]	2006 for roadway, 2008 for residential and non-residential construction,
246102*	Asphalt (cutback and emulsified)	2	CAP and HAP	No		National usage allocated to county by paved road VMT	EIIP 2001 [17]	Asphalt Institute's *2008 Asphalt Usage Survey*	2008
2501011*	Residential Portable Fuel Container	5	VOC And HAP	No		Linear fit between 2002 and 2010 emission estimates	EPA[18]	Nonroad activity from NMIM	2002 grown to 2010 with a linear fit to 2008

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
2501012*	Commercial Portable Fuel Container	5	VOC and HAP	No		Linear fit between 2002 and 2010 emission estimates	EPA[18]	Nonroad activity from NMIM	2002 grown to 2010 with a linear fit to 2008
2501080*	Aviation Petroleum Product use (Stage 1 and 2)	2	VOC and HAP	No		National use allocated by regions and 2008 landing and take-off activity	Four EPA documents	EIA Petroleum Annual Supply, 2008[19]	2008
26100*	Waste Disposal - Open Burning	4	VOC and HAP	No		Per capita emissions including controls	EPA documentation, EF based on 2007 report	EPA Report[20] and construction activity SCC 23110*	2008
2630020000	Waste Disposal Public Treatment	1	VOC and NH3	No		Calculate national emissions, allocate to counties by population	EPA[23,24] reports	EPA Report[22]	2004 and 2010 figures interpolated to 2008
2801700*	Fertilizer Application	14	NH3	No		Activity used in CMU Ammonia Model	CMU Ammonia Model	2002 and 2007 activity from the Fertilizer Institute[21] grown to 2008	grown 2008 figure

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year
28050*	Animal Husbandry (by animal and manure system)	42	NH3	No		CMU Ammonia Model	CMU Ammonia Model	2007 Census of Agriculture[12]	2007

[1] EIA SEDS - Energy Information Administration - State Energy Data System http://www.eia.doe.gov/emeu/states/_seds.html

[2] Employment US Census Bureau *County Business Patterns* http://www.census.gov/epcd/cbp/download/06_data/index.html

[3] Population from US Census http://factfinder.census.gov

[4] Solvent Documentation, Table 2 and Table 3

[5] FHWA HPMS - Federal Highway Administration Highway Performance Monitoring System http://www.fhwa.dot.gov/policy/ohpi/hpms/index.cfm

[6] Huntley, Roy 2009, Criteria Pollutant Emission Factors for ICI Combustion Area Source Categories

[7] DOE - Department of Energy Energy Information Administration *Petroleum Supply Annual 2008, Volume 1,* Table 2

[8] "Gasoline Distribution Industry (Stage 1) - Background Information for Proposed Standards," EPA-453/R94-002a, OAQPS, Jan 1994 and "Gasoline Distribution Industry (Stage 1) - Background Information for Promulgated Standards," EPA-453/R94-002b, OAQPS, Nov 1994

[9] EIIP, Emission Inventory Improvement Program "Volume III: Chapter 11, Gasoline Marketing (Stage I and Stage II), Revised Final", Jan 2001

[10] EIA Energy Information Administration Petroleum Navigator - Product Supplied from http://tonto.eia.doe.gov/dnav/pet/pet_cons_psup_dc_nus_mbblpd_a.htm

[11] AP-42 Section 5.2 "Transportation and Marketing of Petroleum Liquids"

[12] 2007 Census of Agriculture, US Department of Agriculture, http://www.agcensus.usda.gov/

[13] SEPA - Swedish Environmental Protection Agency report 2004-02-02
http://westcoastcollaborative.org/files/sector-marine/SMED%20Methodology%20for%20Calculating%20Emissions%20from%20Ships.pdf

[14] Federal Highway Administration 2007 Highway Statistics http://www.fhwa.dot.gov/policyinformation/statistics/2007/.

[15] Annual Value of Construction http://www.census.gov/const/www/ototpage.html

[16] Asphalt Institute 2008 Survey http://www.asphaltinstitute.org/.

[17] EIIP, Emission Inventory Improvement Program Volume III – Area Sources, Chapter 17, “Asphalt Paving,” 2001

SCC	Category Name	Number of SCCs	Pollutants Included	Point Source Subtraction	Category Submitted by Missouri - Calculation Method	Category Submitted by EPA - Calculation Method	Emission Factor Source	Activity for Category	Activity Base Year

[18] EPA Document *Estimating Emissions from Portable Fuel Containers (PFCs)* http://www.epa.gov/otaq/regs/toxics/420r07001.pdf
[19] EIA 2008 Petroleum Annual Supply, http://www.eia.doe.gov/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/psa_volume1.html
[20] EPA *Municipal Solid Waste in the United States: 2007 Facts and Figures*, EPA530-R-08-010, http://www.epa.gov/epawaste/nonhaz/municipal/pubs/msw07-rpt.pdf
[21] Assn of American Plant Food Control Officials with The Fertilizer Institute, *Commercial Fertilizers 2002 and Commercial Fertilizers 2007*, http://www.aapfco.org/aapfcopubs.html

[22] *Biosolids Generation, Use, and Disposal in the United States*, Table A-8 EPA530-R-99-009, September 1999
[23] EPA EIIP Emission Inventory Improvement Program, April 2004, *Estimating Ammonia Emissions from Anthropogenic Nonagricultural Sources – Draft Final Report*

[24] VOC Emissions from Wastewater Treatment Plants: Characterization, Control, and Compliance, Lewis Publishers, 2003, p. 261

[25] Residential Wood Combustion Tool, http://www.epa.gov/ttn/chief/net/2008inventory.html

3.2.3 Source Category Documentation

The following documentation covers nonpoint categories that were prepared with guidance from EPA and CENRAP. The documentation files include methodologies to be applied nationally, and include Missouri-specific updates and information.

3.2.3.1 Fossil Fuel Combustion – Residential – Coal Combustion

a. Source Category Description

Residential Coal Combustion is coal that is burned to heat residential housing.

The general approach to calculating emissions for these two SCCs is to take State Coal Consumption from the EIA and allocate it to the county level using methods described below. County-level coal consumption is multiplied by the emission factors to calculate emissions.

For this source category, the following SCCs were assigned:

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2104001000	Stationary Source Fuel Combustion	Residential	Anthracite Coal	All Boiler Types
2104002000	Stationary Source Fuel Combustion	Residential	Bituminous/ Subbituminous Coal	All Boiler Types

b. Activity Data

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 2006 Consumption tables published by the Energy Information Administration (EIA).[1] Year 2006 consumption data were used as a surrogate for 2008 emissions because year 2006 data were the latest data available when this inventory was prepared.

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.[2] 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 1 presents the 2006 anthracite and bituminous coal ratios for each state.

State-level coal consumption was allocated to each county using the US Census Bureau's 2000 Census Detailed Housing Information.[3] 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.

c. Control Factors

No controls were assumed for this category

d. Emission Factors

CO emissions were calculated by multiplying the total coal consumed in each county per year by an emission factor. The emission factor is from AP-42.[5] Table 2 presents the CO emission factors for residential anthracite coal combustion (SCC 2104001000) and residential bituminous coal combustion (SCC 2104002000).

e. Sample Calculations

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 (ton/year),
FC_x = annual 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:

$$FC_x = A_{\text{State}} \text{ x } \text{Ratio}_{\text{Anth, Bit}} \text{ x } \text{Ratio}_{\text{County houses}}$$

where:

A_{State} = total tons of coal reported by the EIA,
$\text{Ratio}_{\text{Anth, Bit}}$ = ratio reported in Table 1, and
$\text{Ratio}_{\text{County houses}}$ = county allocation ratio based on number of houses burning coal.

Example:
Using Allegheny County, PA as an example:

The State of Pennsylvania had a reported use of 49,935 tons of coal in the residential sector in 2006.

Statewide Anthracite coal use is calculated using the ratio of Anthracite to Bituminous in Table 1 for PA: 80.64%. 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.

The emission factor for $PM_{2.5}$-PRI (See Table 4) is 0.6 × state-specific % ash content + 0.08 lbs/ton× state-specific % ash content. The ash content is 13.38%, (See Table 2) so the emission factor is 9.09 lbs/ton.

$FC_{Allegheny, anth}$ = 49,935 × 0.8064 × 0.0027 = 109 tons anthracite coal

$Emis_{Allegheny, anth, PM2.5\text{-}PRI}$ = 109 tons Coal × 9.09 lbs $PM_{2.5}$-PRI per ton coal
= 990 lbs $PM_{2.5}$-PRI

f. *References*

1. U.S. Department of Energy, Energy Information Administration (EIA). State Energy Data 2006 Consumption. Washington, DC 2008. Internet Address: http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_all_phy.csv accessed November 2008.

2. 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. Available from: http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/coal_distributions.html, accessed December 2008.

3. U.S. Census Bureau. "Table H40. House Heating Fuel Type", Census 2000: Summary File 3. Internet address: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=&_lang=en&_ts=, accessed July 2009.

4. 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. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/draft1999_residfuel_inven_apr2003.zip accessed November 2004.

5. 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.

6. U.S. Environmental Protection Agency. Emission Inventory Improvement Program. Estimating Ammonia Emissions from Anthropogenic Sources, Draft Final Report. Prepared by E.H. Pechan and Associates, Inc. Research Triangle Park, NC. April 2004.

Table 1. 2006 Anthracite and Bituminous Coal Distribution for the Residential and Commercial Sectors

State	Ratio of Bituminous	Ratio of Anthracite	State	Ratio of Bituminous	Ratio of Anthracite
Alabama	1.0000	0.0000	Montana	1.0000	0.0000
Alaska	1.0000	0.0000	Nebraska	1.0000	0.0000
Arizona	0.8140	0.1860	Nevada	1.0000	0.0000
Arkansas	0.8140	0.1860	New Hampshire	0.0000	1.0000
California	1.0000	0.0000	New Jersey	0.0000	1.0000
Colorado	0.9962	0.0038	New Mexico	1.0000	0.0000
Connecticut	0.0000	1.0000	New York	0.6000	0.4000
Delaware	0.8140	0.1860	North Carolina	1.0000	0.0000
Dist. Columbia	1.0000	0.0000	North Dakota	1.0000	0.0000
Florida	0.8140	0.1860	Ohio	0.8727	0.1273
Georgia	1.0000	0.0000	Oklahoma	0.9167	0.0833
Hawaii	1.0000	0.0000	Oregon	1.0000	0.0000
Idaho	0.9792	0.0208	Pennsylvania	0.1936	0.8064
Illinois	0.9981	0.0019	Rhode Island	0.0000	1.0000
Indiana	0.9474	0.0526	South Carolina	0.9972	0.0028
Iowa	0.9992	0.0008	South Dakota	1.0000	0.0000
Kansas	1.0000	0.0000	Tennessee	0.9939	0.0061
Kentucky	0.9981	0.0019	Texas	0.8140	0.1860
Louisiana	1.0000	0.0000	Utah	1.0000	0.0000
Maine	0.0000	1.0000	Vermont	0.0000	1.0000
Maryland	0.9286	0.0714	Virginia	0.9630	0.0370
Massachusetts	0.5000	0.5000	Washington	1.0000	0.0000
Michigan	0.6667	0.3333	West Virginia	0.9048	0.0952
Minnesota	0.9973	0.0027	Wisconsin	0.9914	0.0086
Mississippi	1.0000	0.0000	Wyoming	1.0000	0.0000
Missouri	1.0000	0.0000			

Table 2. CO Emission Factor for Residential Anthracite Coal Combustion (SCC 2104001000) and Residential Bituminous Coal Combustion (SCC 2104002000): Not Adjusted for Point Source Fuel Consumption

SCC	Pollutant Code	Pollutant Code Description	Factor Numeric Value	Factor Unit Numerator	Factor Unit Denominator
2104001000	CO	CARBON MONOXIDE	275	LB	TON
2104002000	CO	CARBON MONOXIDE	275	LB	TON

3.2.3.2 Fossil Fuel Combustion – Residential – Distillate Oil

a. Source Category Description

Residential Distillate Oil Combustion is oil that is burned in residential housing

The general approach to calculating emissions for this SCC is to take State Distillate Oil Consumption from the EIA and allocate it out to the county level using methods described below. County-level oil consumption is multiplied by the emission factors to calculate emissions.

For this source category, the following SCCs were assigned:

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2104004000	Stationary Source Fuel Combustion	Residential	Distillate Oil	Total Boilers and IC Engines

b. Activity Data

The state-level volume of distillate oil consumed by residential combustion in the U.S. was used to estimate emissions. Distillate oil consumption by energy use sector is presented in State Energy Data 2006 Consumption tables published by the Energy Information Administration (EIA).[1] Year 2006 consumption data were used as a surrogate for 2008 emissions because year 2006 data were the latest data available when this inventory was prepared.

State-level distillate oil consumption was allocated to each county using the US Census Bureau's 2000 Census Detailed Housing Information.[2] These data include the number of housing units using a specific type of fuel for residential heating. State distillate oil consumption was allocated to each county using the ratio of the number of houses burning distillate oil in each county to the total number of houses burning distillate oil in the State.

c. Control Factors

No control measures are assumed for this category.

d. Emission Factors

The CO emission factor for distillate oil is from AP-42.[3] For all counties in the United States, the distillate oil consumed by commercial/institutional combustion is assumed to be No. 2 fuel oil with a heating value of 140,000 Btu per gallon.

e. Sample Calculations

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 $FC_x = A_{State}$ x (H_{county} / H_{State})

where :

A_{State} = State activity data from EIA
H_{County} = number of houses in the county using distillate oil as the primary heating fuel
H_{State} = number of houses in the state using distillate oil as the primary heating fuel

Example:

Using Allegheny County, PA as an example:

The State of Pennsylvania had a reported use of 16,902 thousand barrels of distillate oil in the residential sector in 2006. Allegheny County, PA had 8,123 houses out of the state total of 1,217,155 that use distillate oil as the primary heating fuel. This equates to a share of 0.67% of the distillate oil used for residential heating in the state. From Table 5, 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.

$A_{Alegheny}$ = 16,902 thousand barrels × 8,123 houses / 1,217,155 houses)
× 42 gal / barrel
= 4,737.6 thousand gallons

$Emis_{Alegheny, CO}$ = = 4,737.6 thousand gallons × 5 lb CO/ thousand gallons
= 23,688 lbs CO or 11.8 tons CO

f. References

1. U.S. Department of Energy, Energy Information Administration (EIA). State Energy Data 2006 Consumption. Washington, DC 2008. Internet Address: http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_all_phy.csv, accessed November 2008.

2. U.S. Census Bureau. "Table H40. House Heating Fuel Type", Census 2000: Summary File 3. Internet address: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=&_lang=en&_ts=, accessed July 2009.

3. 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.

4. 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. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/draft1999_residfuel_inven_apr2003.zip accessed November 2004.

5. 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.

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. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/draft1999_residfuel_inven_apr2003.zip accessed November 2004.

8. U.S. Environmental Protection Agency. Emission Factor and Inventory Group. Estimating Ammonia Emissions from Anthropogenic Sources, Draft Report. Prepared by E.H. Pechan and Associates, Inc. Research Triangle Park, NC. September 2003.

Table 1. National Emission Factors for Residential Distillate Oil Combustion

Code	Pollutant	Emission Factor	Emission Factor Numerator	Emission Factor Denominator
CO	Carbon Monoxide	5	LB	E3GAL

3.2.3.3 Fossil Fuel Combustion – Residential - Kerosene

a. Source Category Description

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.

The general approach to calculating emissions for this SCC is to take State Kerosene Consumption from the EIA and allocate it to the county level using methods described below. County-level kerosene consumption is multiplied by the emission factors to calculate emissions.

For this source category, the following SCC was assigned:

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2104011000	Stationary Source Fuel Combustion	Residential	Kerosene	Total: All Combustor Types

b. Activity Data

The volume of kerosene consumed by residential combustion in the U.S. was used to estimate emissions. Kerosene consumption by energy use sector is presented in State Energy Data 2006 Consumption tables published by the Energy Information Administration (EIA).[1] Year 2006 consumption data were used as a surrogate for 2008 emissions because year 2006 data were the latest data available when this inventory was prepared.

State-level kerosene consumption was allocated to each county using the US Census Bureau's 2000 Census Detailed Housing Information.[2] These data include the number of housing units using a specific type of fuel for residential heating. State kerosene consumption was allocated to each county using the ratio of the number of houses burning kerosene in each county to the total number of houses burning kerosene in the State.

c. Control Factors

No control measures are assumed for this category.

d. Emission Factors

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).[3] The CO emission factor is from AP-42.[4]

e. Sample Calculations

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 $FC_x = A_{State} \text{ x } (H_{county} / H_{State})$

where :

A_{State} = State activity data from EIA
H_{County} = number of houses in the county using kerosene as the primary heating fuel
H_{State} = number of houses in the state using kerosene as the primary heating fuel

<u>Example:</u>
Using Allegheny County, PA as an example:

The State of Pennsylvania had a reported use of 1,419.7 thousand barrels of kerosene in the residential sector in 2006. Allegheny County, PA had 8,123 houses out of the state total of 1,217,155 that used kerosene as the primary heating fuel. This equates to a share of 0.67% of the kerosene used for residential heating in the state. From Table 1, CO Emission factor is 202.5 lb/thousand barrels.

E_{CO} = 1,419.7 thousand barrels × (8,123 houses / 1,217,155 houses) × 202.5 lb/thousand barrels
= 1,918.6 lbs CO or 0.96 tons CO

f. References

1. U.S. Department of Energy, Energy Information Administration (EIA). State Energy Data 2006 Consumption. Washington, DC 2008. Internet address: http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_all_phy.csv, accessed November 2008.

2. U.S. Census Bureau. "Table H40. House Heating Fuel Type", Census 2000: Summary File 3. Internet address: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=&_lang=en&_ts=, accessed July 2009.

3. 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.

4. 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. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/draft1999_ residfuel_inven_apr2003.zip accessed November 2004.

5. 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.

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. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/draft1999_ residfuel_inven_apr2003.zip, accessed November 2004.

Table 1. National Emission Factors for Residential Kerosene Combustion

Pollutant Code	Pollutant Code Description	Factor Numeric Value	Factor Unit Numerator	Factor Unit Denominator
CO	CARBON MONOXIDE	202.5	LB	E3BBL

3.2.3.4 Fossil Fuel Combustion – Residential – Natural Gas

a. Source Category Description

Residential Natural Gas Combustion is natural gas that is burned to heat residential housing as well as in grills, hot water heaters, and dryers.

The general approach to calculating emissions for this SCC is to take State Natural Gas Consumption from the EIA and allocate it to the county level using the methods described below. County level natural gas consumption is multiplied by the emission factors to calculate emissions.

For this source category, the following SCC was assigned:

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2104006000	Stationary Source Fuel Combustion	Residential	Natural Gas	Total: Boilers and IC Engines

b. Activity Data

The state-level volume of natural gas consumed by residential combustion in the United States was used to estimate emissions. Natural gas consumption by energy use sector was obtained from the State Energy Data 2006 Consumption tables published by the EIA.[1] Year 2006 consumption data were used as a surrogate for 2008 emissions because these data were the latest data available when this inventory was prepared.

State-level natural gas consumption was allocated to each county using the US Census Bureau's 2000 Census Detailed Housing Information.[2] These data include the number of housing units using a specific type of fuel for residential heating. State natural gas consumption was allocated to each county using the ratio of the number of houses burning natural gas in each county to the total number of houses burning natural gas in the State.

c. Control Factors

No control measures are assumed for this category.

d. Emission Factors

The CO emission factor for natural gas is from AP-42. [3] According to AP-42 (maximum value provided) [2], 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." Some emission factors were revised based on recommendations by an ERTAC advisory panel composed of state and EPA personnel.

County-level CO emissions were calculated by multiplying the total natural gas consumed in each county per year by an emission factor. Table 1 provides a summary of the CO emissions factor for residential combustion of natural gas.

e. Sample Calculations

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 $FC_x = A_{State} \text{ x } (H_{county} / H_{State})$

where :

A_{State} = State activity data from EIA
H_{County} = number of houses in the county using natural gas as the primary heating fuel
H_{State} = number of houses in the state using natural gas as the primary heating fuel

Example:
Using Allegheny County, PA as an example:

The State of Pennsylvania had a reported use of 205,812 million cubic feet of natural gas in the residential sector in 2006. Allegheny County, PA had 474,292 houses out of the state total of 2,452,941 that use natural gas as the primary heating fuel. This equates to a share of 19.34% of the natural gas used for residential heating in the state. From Table 1, CO emission factor is 40 lb/million ft^3.

E_{CO}= 205,812 million ft^3 × (474,292 houses / 2,452,941 houses) × 40 lb CO/ million ft^3

= 1,591,803 lb CO or 795.9 ton CO

f. References

1. U.S. Department of Energy, Energy Information Administration (EIA). State Energy Data 2006 Consumption. Washington, DC 2008. Internet address: http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_all_phy.csv, accessed November 2008.

2. U.S. Census Bureau. "Table H40. House Heating Fuel Type", Census 2000: Summary File 3. Internet address: http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=&_lang=en&_ts=, accessed July 2009.

3. 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.

4. U.S. Environmental Protection Agency. Emission Inventory Improvement Program. Estimating Ammonia Emissions from Anthropogenic Sources, Draft Final Report. Prepared by E.H. Pechan and Associates, Inc. Research Triangle Park, NC. April 2004.

5. 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.

6. 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. Internet address: http://www.epa.gov/ttn/chief/eiip/techreport/volume03/draft1999_ residfuel_inven_apr2003.zip, accessed November 2004.

Table 1. National Criteria Pollutant and HAP Emission Factors for Residential Natural Gas Combustion

Pollutant Code	Pollutant Code Description	Factor Numeric Value	Factor Unit Numerator	Factor Unit Denominator
CO	CARBON MONOXIDE	40	LB	E6FT3

3.2.3.5 Commercial Cooking

a. Source Category Description

Commercial Cooking emissions are for 5 source categories based on equipment type. Emissions estimates are for all types of meat cooked in a particular piece of equipment. Deep fat frying of french fries was also included.

For this source category, the following SCCs were assigned:

Source Classification Code	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four
2302002100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Charbroiling	Conveyorized Charbroiling
2302002200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Charbroiling	Under-fired Charbroiling
2302003000	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Frying	Deep Fat Frying
2302003100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Frying	Flat Griddle Frying
2302003200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Cooking - Frying	Clamshell Griddle Frying

b. Activity Data

Activity data was collected from the US Census Bureau's county level population estimates for July 1, 2008.[1]

c. Control Factors

No controls were assumed for this category.

d. Emission Factors

Emission factors were developed and reviewed by an ERTAC advisory panel composed of state and EPA personnel (Contact: Roy Huntley, huntley.roy@epa.gov). They were created by taking 2002 emissions in the NEI and dividing by the 2002 population to develop per capita emission factors. These emission factors are listed in Table 1.

e. Sample Calculations

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 = population data associated with category x;
$EF_{x,p}$ = emission factor for category x and pollutant p.

<u>Example:</u>
Using conveyorized charbroiling in Allegheny County, PA as an example:

According to the US Census Bureau, population on July 1, 2008 is 1,215,103
The emission factor for VOC is 0.01205 lb/person

$$E_{VOC} = 1{,}215{,}103 \text{ people} \times 0.01205 \text{ lb VOC/ person}$$

$$= 14{,}650 \text{ lb VOC or } 7.3 \text{ ton VOC}$$

f. References

1. DOC, 2008: U.S. Department of Commerce, Bureau of the Census, 2008 *Population Estimates Program GCT-T1: Population Estimates*, Washington, DC.

Table 1: Commercial Cooking Emission Factors Developed by ERTAC

SCC	SCC description	Pollutant Code	Factor Numeric Value	Factor Unit Numerator	Factor Unit Denominator
2302002100	Conveyorized Charbroiling	CO	4.245E-02	LB	EACH
2302002200	Under-fired Charbroiling	CO	1.350E-01	LB	EACH
2302003000	Deep Fat Flying	CO	0.000E+00	LB	EACH
2302003100	Flat Griddle Frying	CO	1.269E-02	LB	EACH
2302003200	Clamshell Griddle Frying	CO	0.000E+00	LB	EACH

3.2.3.6 Open Burning – Land Clearing Debris

a. Source Category Description

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. CO emission estimates from open burning of land clearing debris are a function of the amount of material or fuel subject to burning per year.

For this source category, the following SCC was assigned:

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2610000500	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Land Clearing Debris (use 28-10-005-000 for Logging Debris Burning)

b. Activity Data

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.

Acres Disturbed from Residential Construction

The US Census Bureau has 2008 data for *Housing Starts - New Privately Owned Housing Units Started*[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 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*[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. The table *Annual Housing Units Authorized by Building Permit*[3] has 2007 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. The following surface areas were assumed disturbed for each unit type:

Table 1: Surface Acres Disturbed per Unit Type

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.

Acres Disturbed from Non-Residential Construction

Annual Value of Construction Put in Place in the U.S[4] has the 2008 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*[5] *(CBP)*. Because some counties employment data was 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 guess of the midpoint of the range code was used (so for instance in the 1-19 employees range, a guess of 10 employees would be used) and a state total of the withheld counties was computed.

3. A ratio of guessed employees (Step 2) to withheld employees (Step 1) was then used to adjust the county level guesses 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*[6] lists costs of the construction industry from 1999-2007.

$$\begin{aligned}\text{2007 acres per } \$10^6 &= \text{1999 acres per } \$10^6 \times (\text{1999 PPI / 2007 PPI}) \\ &= 2 \text{ acres/}\$10^6 \ (132.9 / 204.3) \\ &= 1.301 \text{ acres per } \$10^6\end{aligned}$$

<u>Acres Disturbed by Road Construction</u>

The Federal Highway Administration has *Highway Statistics, Section IV - Highway Finance, Table SF-12A, State Highway Agency Capital Outlay*[7] for 2006 which outlines spending by state in several different categories. For this SCC, the following columns are used: New Construction, Relocation, Added Capacity, Major Widening, and Minor Widening. These columns are also differentiated according to the following six classifications:

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 North Carolina Department of Transportation (NCDOT) in 2000. A conversion of $4 million/mile was applied to the interstate expenditures. For expenditures on other arterial and collectors, a conversion factor of $1.9 million/mile was 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 was 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 2 below:

Table 2: Spending per Mile and Acres Disturbed per Mile by Highway Type

Road Type	Thousand Dollars per mile	Acres Disturbed per mile
Urban Areas, Interstate	4000	15.2
Rural Areas, Interstate	4000	15.2
Urban Areas, Other Arterials	1900	15.2
Rural Areas, Other Arterials	1900	12.7
Urban Areas, Collectors	1900	9.8
Rural Areas, Collectors	1900	7.9

Residential building starts are used to allocate the state-level acres disturbed by road construction to the county.[3] 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.

Converting Acres Disturbed to Tons of Land Clearing Debris Burned

Version 2 of the Biogenic Emissions Land cover Database (BELD2) within EPA's Biogenic Emission Inventory System (BEIS) was used to identify the acres of hardwoods, softwoods, and grasses in each county. Table 3 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.[8] 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 3. Fuel Loading Factors by Vegetation Type

Vegetation Type	Unadjusted Average Fuel Loading Factor (Ton/acre)	Adjusted Average Fuel Loading Factor (Ton/acre)
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 in 2008.

c. Controls

Controls for land clearing debris burning are generally in the form of a ban on open burning of waste in a given municipality or county. Counties that were more than 80% urban were assumed not to practice any open burning. Therefore, CO 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.

d. Emission Factors

Emission factors are reported in Table 4 below. The emission factor for CO was 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.[9,10]

e. Emissions

County-level CO emissions (in lb/year) were calculated by multiplying the total mass of land clearing debris burned per year by an emission factor.

f. Example Calculations

VOC emissions in Autauga County, Alabama from open burning of land clearing debris:

Rural fraction of Autauga County population = 0.448, so no emission controls

Acres disturbed by residential, non-residential, and road construction in Autauga County = 434.26

Weighted average fuel loading factor for Autauga County = 65.48 tons/acre

Mass of land clearing debris burned = 434.26 acres * 65.48 tons/acre = 28,437 tons

VOC emission factor = 11.6 lbs/ton

Factor to convert from lbs to tons = 1/2000

VOC emissions = tons of land clearing debris burned * VOC emission factor

VOC emissions from land clearing debris burning = 28,437 tons * 11.6 lbs/ton * 1 ton/2000 lbs

VOC emissions from land clearing debris burning in Autauga County in 2008 = 165 tons

g. References

1. U.S. Census Bureau, "New Privately Owned Housing Units Started for 2008 (Not seasonally adjusted)," available at http://www.census.gov/const/startsua.pdf

2. U.S. Census Bureau, "Table 2au. New Privately Owned Housing Units Authorized Unadjusted Units for Regions, Divisions, and States, Annual 2007" available at http://www.census.gov/const/C40/Table2/tb2u2007.txt

3. Annual Housing Units Authorized by Building Permits CO2007A, purchased from US Department of Census

4. U.S. Census Bureau, "Annual Value of Construction Put in Place," available at http://www.census.gov/const/www/ototpage.html

5. U.S. Census Bureau, "County Business Patterns," available at http://www.census.gov/econ/cbp/index.html

6. Bureau of Labor Statistics, Producer Price Index, Table BMNR, available at http://www.bls.gov/data/

7. Federal Highway Administration, 2006 Highway Spending, available at http://www.fhwa.dot.gov/policy/ohim/hs06/xls/sf12a.xls

8. Ward, D.E., C.C. Hardy, D.V. Sandberg, and T.E. Reinhardt. "Mitigation of Prescribed Fire Atmospheric Pollution through Increased Utilization of Hardwoods, Piled Residues, and Long-Needled Conifers." Final Report. USDA Forest Service, Pacific Northwest Research Station, Fire and Air Resource Management. 1989.

9. Huntley, Roy, U.S. Environmental Protection Agency, "state_comparison ERTAC SS_version7_3 Oct 20 2009 [electronic file]," November 5, 2009.

10. U.S. 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 2.5 Open Burning*. Research Triangle Park, NC. October 1992.

11. U.S. Environmental Protection Agency, "Evaluation of Emissions from the Open Burning of Household Waste in Barrels, EPA-600/R-97-134a," Control Technology Center. November 1997.

12. Gullet, B.K. and T. Abderrahmne, "PCDD/F Emissions from Forest Fire Simulations," *Atmospheric Environment*, Vol. 37, No. 6, pp. 803-813. February 2003.

3.2.3.7 Open Burning – Residential Household Waste

a. Source Category Description

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.

For this source category, the following SCC was assigned:

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2610030000	Waste Disposal, Treatment, and Recovery	Open Burning	Residential	Household Waste (use 26-10-000-xxx for Yard Wastes)

b. Activity Data

The amount of household MSW burned was estimated using data from EPA's report *Municipal Solid Waste in the United States: 2007 Facts and Figures*.[1] The report presents the total mass of waste generated in the United States by type of waste for the calendar year 2007. This information was used to calculate a daily estimate of the per capita household waste subject to burning, 3.40 lbs/person/day. Non-combustible waste, such as glass and metals, was not considered to be waste subject to burning. Burning of yard waste is included in SCC 2610000100 and SCC 2610000400; therefore, it is not part of residential MSW. Approximately 25 to 32 percent of all waste that is subject to open burning is actually burned.[2] A median value of 28 percent is assumed to be burned in all counties in the United States.

Since open burning is generally not practiced in urban areas, only the rural population of each county was assumed to practice open burning. The ratio of urban to rural population was obtained from 2000 U.S. Census data.[3] This ratio was then multiplied by the 2008 U.S. Census Bureau estimate of the population in each county to obtain the county-level rural population for 2008.[4] 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 2008.

c. Controls

Controls for residential MSW burning are generally in the form of a ban on open burning of waste in a given municipality or county. Counties that were more than 80% urban were assumed not to practice any open burning. Therefore, criteria pollutant and HAP emissions from residential municipal solid 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 waste in all Colorado counties were assumed to be zero.

d. Emission Factors

Emission factors are reported in Table 1 below. 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.[5, 6] Emission factors for HAPs are from an EPA Control Technology Center report and emission factors for 17 dioxin congeners were obtained from an EPA dioxin report.[7,8]

e. Emissions

County-level CO emissions were calculated by multiplying the total amount of residential municipal solid waste burned per year by an emission factor.

f. Example Calculations

VOC emissions in Autauga County, Alabama from open burning of residential MSW:

Population of Autauga County in 2008 = 50,364
Rural fraction of Autauga County population = 0.448
Per capita MSW waste generated (lb/person/day) = 3.40

Fraction of rural population that burns MSW = 0.28
Number of days in a year = 365
Factor to convert from lbs to tons = 1/2000

2008 MSW burning activity in Autauga County = 50,364 * 0.448 * 3.40 * 0.28 * 365 * 1/2000

2008 leaf burning activity in Autauga County = 3,921 tons

VOC emissions = tons of leaves burned * VOC emission factor

VOC emission factor = 8.56 lb/ton

VOC emissions from leaf burning in Autauga County in 2008 = 3,921 tons * 8.56 lbs/ton * 1 ton/2000 lbs

VOC emissions from leaf burning in Autauga County in 2008 = 16.78 tons

g. References

1. U.S. Environmental Protection Agency, *Municipal Solid Waste in the United States: 2007 Facts and Figures*, EPA530-R-08-010, Office of Solid Waste and Emergency Response. November 2008. Available at http://www.epa.gov/epawaste/nonhaz/municipal/pubs/msw07-rpt.pdf

2. U.S. Environmental Protection Agency, Region V. "Emission Characteristics of Burn Barrels." Prepared by Two Rivers Regional Council of Public Officials and Patrick Engineering, Inc. June 1994.

3. U.S. Census Bureau, Decennial Censuses, 2000 Census: SF1, Table P2

4. U.S. Census Bureau. *Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2000 to July 1, 2008 (NST-EST2008-01).* Available at http://www.census.gov/popest/states/NST-ann-est.html

5. Huntley, Roy, U.S. Environmental Protection Agency, "state_comparison ERTAC SS_version7_3 Oct 20 2009 [electronic file]," November 5, 2009.

6. 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 2.5 Open Burning*. Research Triangle Park, NC. October 1992.

7. U.S. Environmental Protection Agency, Control Technology Center. "Evaluation of Emissions from the Open Burning of Household Waste in Barrels." EPA-600/R-97-134a. November 1997.

8. United States Environmental Protection Agency, Office of Research and Development. *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzeno-p-Dioxin*

(TCCD) and Related Compounds. Part I: Estimating Exposure to Dioxin-Like Compounds. Volume 2: Sources of Dioxin-Like Compounds in the United States. EPA/600/P-00/001Ab. Washington D.C. March 2001.

Table 1. Emission Factors for Open Burning of Residential MSW (2610030000)

Pollutant	Pollutant Code	Emission Factor (lb/ton)	Emission Factor Reference
CO	CO	8.50E+01	Reference 5

Table 2. Emission Factors for Open Burning of Land Clearing Debris (SCC 2610000500)

Pollutant	Pollutant Code	Emission Factor (lb/ton)	Emission Factor Reference
CO	CO	1.69E+02	Reference 9

3.2.3.8 Open Burning – Yard Waste – Leaf and Brush Species

a. Source Category Description

Open burning of yard waste is the purposeful burning of leaf and brush species in outdoor areas. CO emission estimates for leaf and brush waste burning are a function of the amount of waste burned per year.

For this source category, the following SCCs were assigned:

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2610000100	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Yard Waste – Leaf Species Unspecified
2610000400	Waste Disposal, Treatment, and Recovery	Open Burning	All Categories	Yard Waste – Brush Species Unspecified

b. Activity Data

The amount of leaf and brush waste burned was estimated using data from EPA's report *Municipal Solid Waste in the United States: 2007 Facts and Figures.*[1] The report presents the total mass of waste generated in the United States by type of waste, including yard waste, for the calendar year 2007. This information was used to calculate a daily estimate of the per capita yard waste, 0.59 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.[2]

Open burning of grass clippings is not typically practiced by homeowners, and as such 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.[2] 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 2008 population in each county that is expected to burn waste. Since open burning is generally not practiced in urban areas, only the rural population of each county was assumed to practice open burning. The ratio of urban to rural population was obtained from 2000 U.S. Census data.[3] This ratio was then multiplied by the 2008 U.S. Census Bureau estimate of the population in each county to obtain the county-level rural population for 2008.[4]

The percentage of forested acres from Version 2 of BELD2 within BEIS was used to adjust for variations in vegetation. 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 1 presents the ranges that were used to make adjustments to 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 1. Adjustment for Percentage of Forested Acres

Percent Forested Acres per County	Adjustment for Yard Waste Generated
< 10%	0% generated
>= 10%, and < 50%	50% generated
>= 50%	100% generated

c. Controls

Controls for yard waste burning are generally in the form of a ban on open burning of waste in a given municipality or county. Counties that were more than 80% urban were assumed not to practice any open burning. Therefore, CO emissions from residential municipal solid 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 waste in all Colorado counties were assumed to be zero.

d. Emission Factors

Emission factors are specific to yard waste type and are reported in Tables 2 and 3 below. Emission factors for CAPs were developed by the U.S. Environmental Protection Agency (EPA) in consultation with the Eastern Regional Technical Advisory Committee.[5] Emission factors for HAPs are from AP-42 and an EPA Control Technology Center report.[6, 7]

e. Emissions

County-level CO emissions were calculated by multiplying the total amount of yard waste (either leaf or brush) burned per year by an emission factor. Emissions for leaves and residential brush were calculated separately, since emission factors vary by yard waste type. Tons of debris burned were converted to kilograms (kg) by multiplying by 907.18474.

f. Example Calculations

VOC emissions in Autauga County, Alabama from open burning of leaf waste:

Population of Autauga County in 2008 = 50,364
Rural fraction of Autauga County population = 0.448
Per capita waste yard waste generated (lb/person/day) = 0.59
Leaf fraction of waste = 0.25
Fraction of rural population that burns yard waste = 0.28
Adjustment factor based on % forested acres = 1
Number of days in a year = 365
Factor to convert from lbs to tons = 1/2000

2008 leaf burning activity in Autauga County = 50,364 * 0.448 * 0.59 * 0.25 * 0.28 * 1 * 365 * 1/2000

2008 leaf burning activity in Autauga County = 170.11 tons

VOC emissions = tons of leaves burned * VOC emission factor

VOC emission factor = 28 lb/ton

VOC emissions from leaf burning in Autauga County in 2008 = 170.11 tons * 28 lbs/ton * 1 ton/2000 lbs

VOC emissions from leaf burning in Autauga County in 2008 = 2.38 tons

g. References

1. U.S. Environmental Protection Agency, *Municipal Solid Waste in the United States: 2007 Facts and Figures*, EPA530-R-08-010, Office of Solid Waste and Emergency Response. November 2008. Available at http://www.epa.gov/epawaste/nonhaz/municipal/pubs/msw07-rpt.pdf

2. Two Rivers Regional Council of Public Officials and Patrick Engineering, Inc. "Emission Characteristics of Burn Barrels," prepared for the U.S. Environmental Protection Agency, Region V. June 1994.

3. U.S. Census Bureau, Decennial Censuses, 2000 Census: SF1, Table P2

4. U.S. Census Bureau. *Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2000 to July 1, 2008 (NST-EST2008-01).* Available at http://www.census.gov/popest/states/NST-ann-est.html

5. Huntley, Roy, U.S. Environmental Protection Agency, "state_comparison ERTAC SS_version7_3 Oct 20 2009 [electronic file]," November 5, 2009.

6. U.S. Environmental Protection Agency, Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 2.5 Open Burning,, Tables 2.5-5 and 2.5-6. October 1992.

7. U.S. Environmental Protection Agency, *Evaluation of Emissions from the Open Burning of Household Waste in Barrels*, EPA-600/R-97-134a, Control Technology Center. November 1997.

8. Gullet, B.K. and T. Abderrahmne, "PCDD/F Emissions from Forest Fire Simulations," *Atmospheric Environment*, Vol. 37, No. 6, pp. 803-813. February 2003.

Table 2. Emission Factors for Open Burning of Leaf Species (SCC 2610000100)

Pollutant	Pollutant Code	Emission Factor (lb/ton)	Emission Factor Reference
CO	CO	112	Reference 5

Table 3. Emission Factors for Open Burning of Brush Species (SCC 2610000400)

Pollutant	Pollutant Code	Emission Factor (lb/ton)	Emission Factor Reference
CO	CO	140	Reference 5

3.2.3.9 Fuel Combustion – Industrial and Commercial/Institutional (ICI)

The Central States Regional Planning Association (CENRAP) contracted with Pechan to provide an updated methodology to calculate ICI fuel combustion emissions for 2002, and make the methodology updatable for future inventory projects. Appendix A-5 is documentation of the ICI methodology and describes how it is applied to a revised 2002 inventory.

Statewide emissions are calculated using the fuel activity and emission factors, then statewide point source emission contributions are subtracted, and finally the emissions are allocated to counties. The Energy Information Administration's (EIA's) State Energy Data System (SEDS) provides total energy consumption by sector, but the values have to be adjusted by energy not used for combustion and nonroad equipment use. EIA's *2002 Manufacturing Energy Consumption Survey* (MECS) was used to get regional sectoral energy consumption that is not used for combustion. A run of the NONROAD model for 2006 provided the diesel and LPG quantity to subtract for commercial sector nonroad equipment. Emission factors from Roy Huntley of the EPA, the Emission Inventory improvement Plan (EIIP), and AP-42 cover the various fuel types for criteria pollutants. Emissions from coal combustion require the use of Missouri-specific coal sulfur content from the Energy Information Administration Quarterly Coal Report. Statewide point source emission contributions are subtracted by compiling the sector's CO emissions by Source Classification Code (SCC), which is fuel specific, back-calculating using AP-42 emission factors to a fuel throughput, and subtracting that fuel throughput from the statewide total. Before allocating the remaining nonpoint emissions to Missouri counties, an energy-intensity adjustment is done to account for the variation of energy used per employee for each industrial manufacturing NAICS code. *County Business Patterns* (CBP) published annually by the US Census Bureau outlines employment by NAICS codes and the energy-intensity per employee by NAICS code derived from EIA's 2002 Annual Energy Outlook. Emissions are then allocated to individual counties based on commercial/institutional employment by county and based on energy intensity and employment for the industrial sector.

Appendix A-5 outlines the activity data used, emission factors, and the calculation template spreadsheets for the categories below.

SCC	SCC Description
2102001000	Stationary Source Fuel Combustion; Industrial; Anthracite Coal; Total: All Boiler Types
2102002000	Stationary Source Fuel Combustion; Industrial; Bituminous/Subbituminous Coal; Total: All Boiler Types
2102004000	Stationary Source Fuel Combustion; Industrial; Distillate Oil; Total: Boilers and IC Engines
2102005000	Stationary Source Fuel Combustion; Industrial; Residual Oil; Total: All Boiler Types
2102006000	Stationary Source Fuel Combustion; Industrial; Natural Gas; Total: Boilers and IC Engines
2102007000	Stationary Source Fuel Combustion; Industrial; Liquid Petroleum Gas; Total: All Boiler Types
2102008000	Stationary Source Fuel Combustion; Industrial; Wood; Total: All Boiler Types
2102011000	Stationary Source Fuel Combustion; Industrial; Kerosene; Total: All Boiler Types
2103001000	Stationary Source Fuel Combustion; Commercial/Institutional; Anthracite Coal; Total: All Boiler Types
2103002000	Stationary Source Fuel Combustion; Commercial/Institutional; Bituminous/Subbituminous Coal; Total: All Boiler Types
2103004000	Stationary Source Fuel Combustion; Commercial/Institutional; Distillate Oil; Total: Boilers and IC Engines
2103005000	Stationary Source Fuel Combustion; Commercial/Institutional; Residual Oil; Total: All Boiler Types
2103006000	Stationary Source Fuel Combustion; Commercial/Institutional; Natural Gas; Total: Boilers and IC Engines
2103007000	Stationary Source Fuel Combustion; Commercial/Institutional; Liquid Petroleum Gas; Total: All Combustor Types
2103008000	Stationary Source Fuel Combustion; Commercial/Institutional; Wood; Total: All Boiler Types
2103011000	Stationary Source Fuel Combustion; Commercial/Institutional; Kerosene; Total: All Combustor Types

3.2.3.10 Fossil Fuel Combustion – Residential – Liquefied Petroleum Gas (LPG)

a. Source Category Description

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.

The general approach to calculating emissions for this SCC is to take State LPG Consumption from the EIA and allocate it to the county level using methods described below. County level LPG consumption is multiplied by the emission factors to calculate emissions.

For this source category, the following SCC was assigned:

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2104007000	Stationary Source Fuel Combustion	Residential	Liquefied Petroleum Gas (LPG)	Total: All Combustion Types

b. Activity Data

Residential liquefied petroleum gas (LPG) combustion emissions were calculated using the volume of LPG consumed in the United States. State-level LPG consumption by sector is available from the Energy Information Administration (EIA).[1] Year 2006 consumption data were used as a surrogate for 2008 emissions because these were the latest data available when this inventory was prepared.

State-level LPG consumption was allocated to each county using the US Census Bureau's 2000 Census Detailed Housing Information.[2] These data include the number of housing units using a specific type of fuel for residential heating. State LPG consumption was allocated to each county using the ratio of the number of houses burning LPG in each county to the total number of houses burning LPG in the State.

c. Control Factors

No control measures are assumed for this category.

d. Emission Factors

Pollutant emission factors for residential LPG are based on the residential natural gas emission factors.[3,4,5] 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.[3] 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.

e. Sample Calculations

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 LPG as the primary heating fuel
H_{State} = number of houses in the state using LPG as the primary heating fuel.

Example:

Using Allegheny County, PA as an example:

The State of Pennsylvania had a reported use of 4,743 thousand barrels of LPG in the residential sector in 2006. Allegheny County, PA had 4,317 houses out of the state total of 145,254 that use LPG as the primary heating fuel. This equates to a share of 2.97% of the LPG used for residential heating in the state. From Table 1, CO emission factor is 159.6 lb/thousand barrels.

E_{CO} = 4,743 thousand barrels × (4,317 houses / 145,254 houses)
× 159.6 lb/thousand barrels

= 22,498 lb CO or 11.25 tons CO

f. References

1. U.S. Department of Energy, Energy Information Administration (EIA). State Energy Data 2006 Consumption. Washington, DC 2008. Internet address: http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_all_phy.csv, accessed November 2008.

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Table 1. National CO Emission Factor for Residential LPG Combustion

Pollutant Code	Pollutant Code Description	Factor Numeric Value	Factor Unit Numerator	Factor Unit Denominator
CO	CO	159.6	LB	E3BBL

3.2.3.11 Fuel Combustion – Residential- Wood

EPA created the Residential Wood Combustion tool to assist states with compiling the 2005 NEI, and has updated the tool with new SCCs to reflect new equipment (certified/ non-certified inserts, outdoor hydronic heaters, wood pellet stoves), revised equipment population based on regional surveys and American Housing Survey (US Census) data, and wood use ratios.

The tool is a Microsoft Access database with data input tables for appliance types and population, fuel inputs, burn temporal profiles, and emission factors. Missouri had no state-specific updates to input files, so the EPA defaults for Missouri were used to calculate emissions. A specific query is run that performs the calculation and outputs the emission table for the state or counties of interest.

3.2.4 Nonpoint Source Emission Summary

Table 9 Nonpoint CO Emissions for St. Louis City and St. Louis County (tons per year)

County Name	CO Emissions
St. Louis County	8,752.71
St. Louis City	3,086.57
Totals	**11,839.27**

3.3 Mobile Source Emissions

3.3.1 Nonroad Mobile Sources

Nonroad categories include recreational marine and land-based vehicles, farm and construction machinery, industrial, commercial, logging, and lawn and garden equipment, and railway maintenance equipment. These types of equipment are powered by compression-ignition engines which are typically diesel-fueled, as well as spark-ignition (gasoline-fueled) engines. Compressed natural gas (CNG) and liquefied petroleum gas (LPG) engines may also power certain types of nonroad equipment.

3.3.1.1 Procedures and Methodologies

For nonroad gasoline, diesel, LPG and CNG sources, EPA's National Mobile Inventory Model (NMIM), incorporating the NONROAD2008 model, was used to calculate nonroad emissions. The annual CO emissions data generated by EPA for the 2008 off-road mobile source emissions for the St. Louis City and St. Louis County are summarized in Table .

For aircraft, EPA ran the Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) using Bureau of Transportation Statistics (BTS) T-100 Landing and Takeoff (LTO) and Terminal Area Forecast (TAF) data. The state of Missouri did not provide alternate emissions or input data, so EPA calculations were accepted.

For commercial marine vehicles, EPA's Office of Transportation and Air Quality (OTAQ) provided emission estimates based on grown 2002 emissions and 2008 Locomotive and Marine federal rule making. Again, EPA emission estimates were accepted.

For locomotives, the Eastern Regional Technical Advisory Committee (ERTAC Rail) provided emission estimates based on fuel use data from the American Association of Railroads (AAR), Surface Transportation Board (STB) Annual Reports, and railroad provided fleet and activity information. These estimates were accepted by Missouri.

EPA generates emissions data for commercial marine and locomotive sources using a method similar to the way emissions are generated for non-point sources. Therefore, 2008 NEI data for commercial marine and locomotive emissions, which are listed as nonpoint emissions in the NEI data, need to be added to the nonroad mobile source category. See Section 3.3.1.4 for emission totals.

3.3.1.2 List of Source Categories and Emissions

The list of source categories and emissions in St. Louis City and St. Louis County is provided in Appendix A-4. EPA's NONROAD 2008a model was used to generate the nonroad emission summary listed in table 10.

3.3.1.3 Source Category Documentation

EPA's NONROAD 2008a model was used to generate the nonroad emission summary listed in table 10; this does not include emissions from locomotive and marine engines. The methodology for calculating locomotive and marine engines can be found in Appendix A-3. The emissions for these two source categories are listed in Table 11, and the total annual nonroad CO emissions for St. Louis City and St. Louis County are listed in Table 12.

3.3.1.4 Nonroad Source Emission Summary

Table 10 St. Louis County and City 2008 Nonroad Emissions (excluding Marine,Rail,andAir Emissions)

Area	CO Emissions (tons/year)
St. Louis County	75,892.69
St. Louis City	14,001.59
Totals	**89,894.28**

Table 11 St. Louis County and City 2008 Marine, Rail, and Air Emissions

Area	CO Emissions (tons/year)
St. Louis County	1,548.15
St. Louis City	1,581.52
Totals	**3,129.67**

Table 12 St. Louis County and City Total 2008 Nonroad Mobile Source Emissions

Area	CO Emissions (tons/year)
St. Louis County	77,440.84
St. Louis City	15,583.11
Totals	**93,023.95**

3.3.2 Onroad Mobile Sources

Onroad emission sources are also known as highway sources. They include vehicles used on roads for transportation of passengers or freight. The emissions from internal combustion engines in these vehicles are included in this category.

3.3.2.1 Mobile Model Choice

EPA released the Mobile Vehicle Emission System (MOVES) in December of 2010, and MOVES is now the official model to use for mobile emissions modeling. MOVES was chosen because it is the official model for future inventories and to ensure that grown emissions and budgets will be calculated consistently. 2008 mobile emissions were initially created using Mobile6.2 via NMIM for the St. Louis nonattainment area for the purpose of submitting state wide emissions data for EPA's 2008 National Emissions Inventory (NEI). The NMIM NCD input data was updated with Missouri specific information. Local VMT data, vehicle registration distributions, and meteorology data from the updated NCD were converted to MOVES formatting using EPA provided conversion workbooks.

MOVES is a completely redesigned model, not just an updated version of the previous Mobile model. The way MOVES calculates emissions has changed to reflect EPA's more current understanding of the emissions produced by vehicles and the various factors that affect the emissions.

3.3.2.2 Mobile Model Inputs

Local VMT data was gathered from East-West Gateway at the county level. This data is listed in Table 13.

The road type distribution in the baseyearvmt table from the NCD was used to distribute the county level VMT to road type. EPA's VMT converter workbook was then used to produce MOVES input tables.

An age distribution for light duty vehicles was created from a list of Vehicle Identification Numbers (VINs) contained in vehicle registration records from the Missouri Department of Revenue. The VINs were decoded into model year and MOBILE6 vehicle classes by ESP Data Solutions, Inc, a private contractor. A specific registration distribution was created for the five county Missouri portion of the St. Louis Nonattainment area. This data updated the BaseYearVMT Table and the CountyYear Table. The vehicle distribution was converted to MOVES age distribution table using EPA's VMT converter workbook. The registration data was also used to create the MOVES vehicle population input tables. Vehicle counts were converted from Mobile 6.2 vehicle classes to MOVES source types using the source type fractions from the Source Type Pop Fractions table in EPA's VMT converter workbook. The vehicle distribution is listed in Table 14.

St. Louis City and St. Louis County both participate in the Gateway Vehicle Inspection Program (GVIP). For counties subject to Emission Inspection/Maintenance (I/M) Programs, MOVES allows for an I/M input table to be created. An I/M input table was created to describe the GVIP for St. Louis City and St. Louis County. Development of the table was in accordance with EPA technical guidance on appropriate input assumptions and sources of data for the use of MOVES 2010 in State Implementation Plans (http://www.epa.gov/otaq/models/moves/420b10023.pdf). Documentation for the development protocol for the I/M input table can be found in Appendix A-6.

MOVES base data was used for all other inputs, after reviewing the data to ensure accuracy. The base fuel supply tables in MOVES were used for the runs, as they already took into account the reformulated gasoline used in the St. Louis nonattainment area. A separate input database was created for each county, using county specific data where possible. The MOVES input tables, other than default EPA templates, are included in Table 15 through Table .

Table 13 2008 Vehicle Miles Traveled by County

County FIPS	County_Name	VMT* in Million Miles
1	Adair County	159.4784
3	Andrew County	319.5966
5	Atchison County	196.4741
7	Audrain County	240.2153
9	Barry County	356.2431
11	Barton County	228.2903
13	Bates County	276.5227
15	Benton County	213.8250
17	Bollinger County	117.7653
19	Boone County	1,484.7484
21	Buchanan County	751.9344
23	Butler County	488.9247
25	Caldwell County	154.1807
27	Callaway County	913.0340
29	Camden County	491.0100
31	Cape Girardeau County	722.6664
33	Carroll County	96.9629
35	Carter County	122.2928
37	Cass County	947.9729
39	Cedar County	113.8193
41	Chariton County	85.0137
43	Christian County	721.9733
45	Clark County	139.0347
47	Clay County	2,256.7113
49	Clinton County	320.3453
51	Cole County	618.3292
53	Cooper County	479.2263
55	Crawford County	491.5010
57	Dade County	77.8041
59	Dallas County	193.3356
61	Daviess County	267.3748
63	DeKalb County	199.1815
65	Dent County	149.0151
67	Douglas County	127.5733
69	Dunklin County	317.1931
71	Franklin County	1,636.7261
73	Gasconade County	156.4525
75	Gentry County	58.3613
77	Greene County	2,404.9309
79	Grundy County	80.0101
81	Harrison County	274.5483
83	Henry County	310.2750
85	Hickory County	97.5059
87	Holt County	259.7343
89	Howard County	99.7101
91	Howell County	470.7985

County FIPS	County_Name	VMT* in Million Miles
121	Macon County	242.8909
123	Madison County	138.1476
125	Maries County	122.7927
127	Marion County	354.5883
129	Mercer County	52.8821
131	Miller County	348.3599
133	Mississippi County	241.8438
135	Moniteau County	141.0637
137	Monroe County	91.6368
139	Montgomery County	381.1052
141	Morgan County	221.8110
143	New Madrid County	483.9027
145	Newton County	791.7511
147	Nodaway County	188.0544
149	Oregon County	151.1144
151	Osage County	176.1925
153	Ozark County	115.5051
155	Pemiscot County	491.2463
157	Perry County	299.3293
159	Pettis County	406.5007
161	Phelps County	711.2055
163	Pike County	276.9507
165	Platte County	1,363.4685
167	Polk County	355.0242
169	Pulaski County	537.7921
171	Putnam County	52.0246
173	Ralls County	202.9427
175	Randolph County	289.3356
177	Ray County	190.6346
179	Reynolds County	88.8169
181	Ripley County	110.1861
183	St. Charles County	2,727.9563
185	St. Clair County	182.8044
186	Ste. Genevieve County	398.6384
187	St. Francois County	548.1491
189	St. Louis County	11,925.1835
195	Saline County	463.6895
197	Schuyler County	62.0992
199	Scotland County	51.6444
201	Scott County	471.9991
203	Shannon County	119.4785
205	Shelby County	99.2628
207	Stoddard County	363.2309
209	Stone County	312.0035
211	Sullivan County	65.6205
213	Taney County	642.9550

County FIPS	*County_Name*	*VMT* in Million Miles*
93	Iron County	126.2972
95	Jackson County	6,713.6034
97	Jasper County	1,067.1157
99	Jefferson County	1,884.7099
101	Johnson County	499.5025
103	Knox County	57.7446
105	Laclede County	652.5356
107	Lafayette County	692.2315
109	Lawrence County	656.1909
111	Lewis County	166.5792
113	Lincoln County	495.2502
115	Linn County	153.6966
117	Livingston County	170.1267
119	McDonald County	330.7242

County FIPS	*County_Name*	*VMT* in Million Miles*
215	Texas County	322.3266
217	Vernon County	345.9822
219	Warren County	524.8759
221	Washington County	220.3597
223	Wayne County	183.2741
225	Webster County	662.7641
227	Worth County	18.6762
229	Wright County	278.1377
510	St. Louis City	3,450.4882

*From MoDOT except for Cass, Clay, Jackson, and Platte (MARC) and Franklin, Jefferson, St. Charles, St. Louis, and St. Louis City (East-West Gateway)

Table 14 Missouri Registration Distribution

Vehicle Class	Vehicle Model Year Population Percentage Per Vehicle Classification												
	2008	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**	**1996**
LDV	0.0248	0.0564	0.0666	0.0649	0.0653	0.0632	0.0633	0.0679	0.0675	0.0652	0.0604	0.0501	0.0488
LDT1	0.0130	0.0345	0.0103	0.0666	0.0759	0.0255	0.0713	0.0780	0.0859	0.0487	0.0474	0.0398	0.0379
LDT2	0.0179	0.0593	0.0700	0.0750	0.0840	0.0759	0.0728	0.0808	0.0671	0.0640	0.0563	0.0522	0.0427
LDT3	0.0161	0.0734	0.0630	0.0760	0.0785	0.0842	0.0838	0.0728	0.0624	0.0539	0.0561	0.0365	0.0328
LDT4	0.0153	0.0843	0.1358	0.0771	0.0953	0.1119	0.0736	0.0461	0.0564	0.0549	0.0715	0.0395	0.0342
HDV2b	0.0078	0.0468	0.0483	0.0729	0.0660	0.0808	0.0871	0.0713	0.0773	0.0671	0.0642	0.0310	0.0519
HDV3	0.0066	0.0628	0.0602	0.0961	0.0876	0.0681	0.0715	0.0613	0.0774	0.0669	0.0734	0.0272	0.0331
HDV4	0.0040	0.0200	0.0638	0.0404	0.0338	0.0366	0.0385	0.0413	0.0653	0.0781	0.0821	0.0383	0.0630
HDV5	0.0187	0.1207	0.0664	0.0804	0.0535	0.0639	0.0560	0.0450	0.0578	0.0951	0.0899	0.0465	0.0572
HDV6	0.0311	0.0355	0.1005	0.0865	0.0529	0.0268	0.0212	0.0199	0.0840	0.0765	0.0685	0.0572	0.0591
HDV7	0.0182	0.0324	0.1250	0.1080	0.1033	0.0772	0.0847	0.0669	0.0285	0.0427	0.0285	0.0253	0.0281
HDV8a	0.0136	0.0110	0.0524	0.0497	0.0565	0.0513	0.0420	0.0301	0.0426	0.0791	0.0570	0.0386	0.0354
HDV8b	0.0189	0.0726	0.2263	0.0348	0.0639	0.0957	0.0899	0.0552	0.0522	0.1363	0.0697	0.0305	0.0203
HDBS	0.0343	0.0556	0.0925	0.0556	0.1004	0.0587	0.0623	0.0351	0.0489	0.0657	0.0669	0.0678	0.0426
HDBT	0.0060	0.0045	0.0132	0.0144	0.0138	0.0291	0.0378	0.0258	0.0249	0.0390	0.0351	0.0309	0.0351
MC	0.0190	0.0646	0.1035	0.1096	0.1172	0.0874	0.0922	0.0713	0.0610	0.0435	0.0360	0.0255	0.0208
	1995	**1994**	**1993**	**1992**	**1991**	**1990**	**1989**	**1988**	**1987**	**1986**	**1985**	**1984**	
LDV	0.0390	0.0420	0.0313	0.0274	0.0213	0.0184	0.0138	0.0121	0.0083	0.0065	0.0049	0.0106	
LDT1	0.0443	0.0211	0.0168	0.0210	0.0189	0.0193	0.0184	0.0363	0.0582	0.0433	0.0250	0.0426	
LDT2	0.0292	0.0287	0.0266	0.0215	0.0157	0.0149	0.0096	0.0096	0.0076	0.0054	0.0042	0.0090	
LDT3	0.0322	0.0423	0.0338	0.0207	0.0181	0.0106	0.0112	0.0104	0.0070	0.0067	0.0058	0.0117	
LDT4	0.0201	0.0158	0.0145	0.0101	0.0074	0.0055	0.0052	0.0063	0.0074	0.0045	0.0014	0.0059	
HDV2b	0.0350	0.0393	0.0244	0.0196	0.0151	0.0122	0.0124	0.0154	0.0097	0.0062	0.0102	0.0280	
HDV3	0.0266	0.0340	0.0223	0.0165	0.0122	0.0126	0.0134	0.0118	0.0126	0.0096	0.0098	0.0264	
HDV4	0.0504	0.0723	0.0647	0.0308	0.0247	0.0243	0.0238	0.0270	0.0198	0.0121	0.0128	0.0321	
HDV5	0.0517	0.0217	0.0147	0.0083	0.0067	0.0110	0.0113	0.0125	0.0080	0.0012	0.0000	0.0018	
HDV6	0.0557	0.0389	0.0134	0.0152	0.0093	0.0162	0.0292	0.0196	0.0184	0.0240	0.0062	0.0342	
HDV7	0.0253	0.0321	0.0174	0.0202	0.0158	0.0166	0.0139	0.0226	0.0162	0.0178	0.0103	0.0230	
HDV8a	0.0333	0.0786	0.0447	0.0381	0.0239	0.0228	0.0291	0.0360	0.0277	0.0261	0.0163	0.0641	
HDV8b	0.0087	0.0015	0.0015	0.0029	0.0044	0.0044	0.0029	0.0044	0.0000	0.0000	0.0015	0.0015	
HDBS	0.0489	0.0327	0.0185	0.0146	0.0106	0.0095	0.0114	0.0173	0.0024	0.0035	0.0032	0.0410	
HDBT	0.0830	0.0836	0.0492	0.0441	0.0267	0.0399	0.0609	0.0333	0.0558	0.0540	0.0351	0.1248	
MC	0.0189	0.0171	0.0122	0.0119	0.0073	0.0063	0.0063	0.0064	0.0054	0.0068	0.0097	0.0401	

Table 15 2008 Source Type Population

			Source Type Population by County	
YearID	**SourceTypeName**	**SourceTypeID**	**St Louis County**	**St Louis City**
2008	Motorcycle	11	19,243	3104
2008	Passenger Car	21	527,148	125,776
2008	Passenger Truck	31	303,295.72	59,405.61
2008	Light Commercial Truck	32	97,845.28	20,194.39
2008	Refuse Truck	41	93.5	69.5
2008	Single Unit Short-haul Truck	42	280.5	208.5
2008	Single Unit Long-haul Truck	43	2,709.24	661
2008	Motor Home	51	50.14	16.25
2008	School Bus	52	3,623.55	1,249.2
2008	Transit Bus	53	270.27	92.6
2008	Intercity Bus	54	378.69	143.45
2008	Combination Short-haul Truck	61	791.19	247.5
2008	Combination Long-haul Truck	62	544.92	160

Table 16 2008 Annual VMT by HPMS Vehicle Type, County, and Year

			HPMSBaseYearVMT by County	
HPMSVtypeID	**HPMSVtypeName**	**YearID**	**St. Louis**	**St. Louis City**
10	Motorcycles	2008	91,989,970	26,665,063
20	Passenger Cars	2008	5,115,865,231	1,477,495,621
30	Other 2 axle-4 tire vehicles	2008	5,875,722,138	1,702,465,533
40	Buses	2008	35,928,481	10,469,862
50	Single Unit Trucks	2008	207,228,073	59,856,119
60	Combination Trucks	2008	598,448,609	173,536,046

Table 17 Age Distribution by Source Type

	Source Type ID												
AgeID	**11**	**21**	**31**	**32**	**41**	**42**	**43**	**51**	**52**	**53**	**54**	**61**	**62**
0	0.019	0.0248	0.016038	0.015215	0.006	0.006	0.03372	0.019407	0.022549	0.022677	0.024421	0.018826	0.017834
1	0.0646	0.0564	0.059034	0.058508	0.0045	0.0045	0.054157	0.048521	0.039325	0.03937	0.032671	0.049995	0.052613
2	0.1035	0.0666	0.063189	0.062229	0.0132	0.0132	0.092687	0.158149	0.129508	0.130555	0.106219	0.16227	0.169835
3	0.1096	0.0649	0.073971	0.073529	0.0144	0.0144	0.057163	0.057986	0.082002	0.084645	0.091592	0.052692	0.04403
4	0.1172	0.0653	0.081725	0.079405	0.0138	0.0138	0.098055	0.068814	0.07432	0.076743	0.07138	0.066656	0.063479
5	0.0874	0.0632	0.072225	0.07206	0.0291	0.0291	0.05743	0.075516	0.060754	0.062113	0.04642	0.077218	0.080584
6	0.0922	0.0633	0.075227	0.075017	0.0378	0.0378	0.060728	0.071294	0.059753	0.061551	0.046468	0.072242	0.074392
7	0.0713	0.0679	0.075731	0.074101	0.0258	0.0258	0.034794	0.048222	0.045101	0.04668	0.038418	0.04791	0.047775
8	0.061	0.0675	0.069095	0.069315	0.0249	0.0249	0.049567	0.050551	0.053801	0.053336	0.05744	0.050259	0.049622
9	0.0435	0.0652	0.059343	0.060606	0.039	0.039	0.065329	0.101607	0.075238	0.074281	0.059218	0.106403	0.114631
10	0.036	0.0604	0.056546	0.058019	0.0351	0.0351	0.065952	0.060365	0.052757	0.052173	0.04901	0.061907	0.064481
11	0.0255	0.0501	0.045379	0.044021	0.0309	0.0309	0.066337	0.035034	0.038694	0.038608	0.041544	0.03448	0.033479
12	0.0208	0.0488	0.040069	0.041299	0.0351	0.0351	0.042714	0.030037	0.038252	0.038379	0.043733	0.028628	0.026173
13	0.0189	0.039	0.031719	0.032547	0.083	0.083	0.048635	0.022609	0.033622	0.033505	0.041779	0.020871	0.017769
14	0.0171	0.042	0.029341	0.030746	0.0836	0.0836	0.033323	0.026945	0.032499	0.031744	0.038573	0.026434	0.025331
15	0.0122	0.0313	0.025132	0.025766	0.0492	0.0492	0.018302	0.014853	0.01522	0.015277	0.015313	0.014766	0.014626
16	0.0119	0.0274	0.020261	0.020238	0.0441	0.0441	0.01489	0.014543	0.016624	0.016485	0.018482	0.014281	0.013778
17	0.0073	0.0213	0.01591	0.015912	0.0267	0.0267	0.010657	0.011093	0.012019	0.01218	0.012215	0.010861	0.010491
18	0.0063	0.0184	0.014002	0.013972	0.0399	0.0399	0.009968	0.011696	0.014667	0.014636	0.016859	0.011229	0.010394
19	0.0063	0.0138	0.011117	0.011398	0.0609	0.0609	0.012691	0.012448	0.018417	0.017168	0.026192	0.012123	0.011221
20	0.0064	0.0121	0.014109	0.014268	0.0333	0.0333	0.018084	0.014903	0.019136	0.018141	0.024946	0.014734	0.014172
21	0.0054	0.0083	0.015761	0.015219	0.0558	0.0558	0.00363	0.01022	0.014831	0.014247	0.019752	0.009773	0.008829
22	0.0068	0.0065	0.011686	0.011205	0.054	0.054	0.00501	0.010636	0.017272	0.016478	0.024234	0.009966	0.008574
23	0.0097	0.0049	0.00791	0.008124	0.0351	0.0351	0.003627	0.006385	0.007661	0.00744	0.00919	0.006293	0.006072
24	0.013837	0.003694	0.00582	0.006825	0.022815	0.022815	0.003017	0.003218	0.003631	0.003569	0.004095	0.003185	0.003108
25	0.019738	0.002785	0.004029	0.004856	0.01483	0.01483	0.002668	0.001864	0.001955	0.001889	0.002204	0.001885	0.001903
26	0.006525	0.002099	0.002201	0.002308	0.009639	0.009639	0.002379	0.001137	0.001109	0.001082	0.001162	0.001156	0.001183
27	0	0.001582	0.001069	0.001073	0.006266	0.006266	0.00214	0.00071	0.000645	0.000647	0.000595	0.000721	0.000739
28	0	0.00044	0.000253	0.000245	0.004073	0.004073	0.001953	0.000417	0.000378	0.000362	0.000398	0.000432	0.000454
29	0	0	0.000147	0.000139	0.002647	0.002647	0.001784	0.00024	0.000223	0.000197	0.000282	0.000256	0.000278
30	0	0	0.001957	0.001836	0.064531	0.064531	0.028609	0.010581	0.018036	0.013841	0.035194	0.011546	0.012147

Table 18 Inspection and Maintenance Data for 2008

Pol ProcessID	stateID	yearID	Source typeID	Fuel TypeID	IM ProgramID	Inspect Freq	Test StandardsID	Beg Model YearID	End Model YearID	Use IMyn	Compliance Factor
101	29	2008	21	1	1	1	11	1971	1995	N	93.12
101	29	2008	21	1	10	2	51	1996	2006	Y	97.94
101	29	2008	31	1	1	1	11	1971	1995	N	93.12
101	29	2008	31	1	10	2	51	1996	2006	Y	92.06
101	29	2008	32	1	1	1	11	1971	1995	N	93.12
101	29	2008	32	1	10	2	51	1996	2006	Y	86.18
102	29	2008	21	1	1	1	11	1971	1995	N	93.12
102	29	2008	21	1	10	2	51	1996	2006	Y	97.94
102	29	2008	31	1	1	1	11	1971	1995	N	93.12
102	29	2008	31	1	10	2	51	1996	2006	Y	92.06
102	29	2008	32	1	1	1	11	1971	1995	N	93.12
102	29	2008	32	1	10	2	51	1996	2006	Y	86.18
112	29	2008	21	1	7	1	41	1971	1995	N	93.12
112	29	2008	21	1	8	2	43	1996	2006	Y	97.94
112	29	2008	31	1	7	1	41	1971	1995	N	93.12
112	29	2008	31	1	8	2	43	1996	2006	Y	92.06
112	29	2008	32	1	7	1	41	1971	1995	N	93.12
112	29	2008	32	1	8	2	43	1996	2006	Y	86.18
113	29	2008	21	1	7	1	41	1971	1995	N	93.12
113	29	2008	21	1	8	2	43	1996	2006	Y	97.94
113	29	2008	31	1	7	1	41	1971	1995	N	93.12
113	29	2008	31	1	8	2	43	1996	2006	Y	92.06
113	29	2008	32	1	7	1	41	1971	1995	N	93.12
113	29	2008	32	1	8	2	43	1996	2006	Y	86.18
201	29	2008	21	1	1	1	11	1971	1995	N	93.12
201	29	2008	21	1	10	2	51	1996	2006	Y	97.94
201	29	2008	31	1	1	1	11	1971	1995	N	93.12
201	29	2008	31	1	10	2	51	1996	2006	Y	92.06
201	29	2008	32	1	1	1	11	1971	1995	N	93.12

Pol ProcessID	stateID	yearID	Source typeID	Fuel TypeID	IM ProgramID	Inspect Freq	Test StandardsID	Beg Model YearID	End Model YearID	Use IMyn	Compliance Factor
201	29	2008	32	1	10	2	51	1996	2006	Y	86.18
202	29	2008	21	1	1	1	11	1971	1995	N	93.12
202	29	2008	21	1	10	2	51	1996	2006	Y	97.94
202	29	2008	31	1	1	1	11	1971	1995	N	93.12
202	29	2008	31	1	10	2	51	1996	2006	Y	92.06
202	29	2008	32	1	1	1	11	1971	1995	N	93.12
202	29	2008	32	1	10	2	51	1996	2006	Y	86.18
301	29	2008	21	1	10	2	51	1996	2006	Y	97.94
301	29	2008	31	1	10	2	51	1996	2006	Y	92.06
301	29	2008	32	1	10	2	51	1996	2006	Y	86.18
302	29	2008	21	1	10	2	51	1996	2006	Y	97.94
302	29	2008	31	1	10	2	51	1996	2006	Y	92.06
302	29	2008	32	1	10	2	51	1996	2006	Y	86.18

Table 19 Fuel Formulation for 2008

Fuel FormulationID	Fuel SubtypeID	FuelSubtypeDesc	RVP	Sulfur Level	ETOH Volume	MTBE Volume	ETBE Volume	TAME Volume	Aromatic Content	Olefin Content
2302	12	Gasohol (E10)	11.2917	43.0622	10	0	0	0	20.2606	8.39154
2303	12	Gasohol (E10)	8.75115	46.6452	10	0	0	0	18.9623	8.14345
2304	12	Gasohol (E10)	6.84571	49.3325	10	0	0	0	17.9886	7.95739
2305	12	Gasohol (E10)	13.1972	40.375	10	0	0	0	21.2343	8.57759
20043	20	Conventional Diesel	0	43	0	0	0	0	0	0

Fuel FormulationID	Fuel SubtypeID	fuelSubtypeDesc	Benzene Content	e200	e300	biodiesel EsterVolume	cetaneIndex	PAHContent
2302	12	Gasohol (E10)	0.848747	56.4983	84.16	0	0	0
2303	12	Gasohol (E10)	0.763743	53.3414	85.1429	0	0	0
2304	12	Gasohol (E10)	0.69999	50.9738	85.88	0	0	0
2305	12	Gasohol (E10)	0.9125	58.8659	83.4229	0	0	0
20043	20	Conventional Diesel	0	0	0	0	0	0

Table 20 2008 Fuel Supply

FuelYearID	Month GroupID	Fuel FormulationID	Market Share	Market ShareCV
2008	1	2305	1	0.5
2008	1	20043	1	0.5
2008	2	20043	1	0.5
2008	2	2302	1	0.5
2008	3	2302	1	0.5
2008	3	20043	1	0.5
2008	4	20043	1	0.5
2008	4	2303	1	0.5
2008	5	2303	1	0.5
2008	5	20043	1	0.5
2008	6	20043	1	0.5
2008	6	2304	1	0.5
2008	7	2304	1	0.5
2008	7	20043	1	0.5
2008	8	20043	1	0.5
2008	8	2304	1	0.5
2008	9	2304	1	0.5
2008	9	20043	1	0.5
2008	10	20043	1	0.5
2008	10	2303	1	0.5
2008	11	2302	1	0.5
2008	11	20043	1	0.5
2008	12	20043	1	0.5
2008	12	2302	1	0.5

Table 21 Average Monthly Temperatures by Hour of the Day for St. Louis County in Fahrenheit

	MonthID											
HourID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	25.5	28.1	39	48.2	56.2	70.2	71.8	68.8	62.4	50.7	38.8	24.4
2	24.5	26.6	37.3	46.2	55	69.1	70.6	68.1	62.5	49.8	38.6	24.6
3	23.6	25.2	36.1	45.1	53.8	68	69.9	67.2	61.6	49.1	37.8	23.9
4	22.7	24.5	35.1	44.3	52.8	67	69.6	66.5	60.9	48.4	37	23.2
5	21.9	23.9	34.2	43.6	52.1	66.1	68.9	65.9	60.4	47.6	36.3	22.5
6	21.4	23.4	33.1	43.3	51.6	65.6	68.4	65.3	59.9	47.1	35.6	22.5
7	21.2	23.1	32.6	43.3	53.2	67.7	69.7	65.8	59.8	46.6	35	22.5
8	21.2	22.7	32.9	45.7	56.5	70.9	72.5	69.4	61.9	47.9	34.9	22
9	22.5	24.1	36.4	48.9	59.4	73.9	75.7	72.8	65.2	52.2	37.8	23.9
10	26.6	26.7	39.8	51.8	62.5	76.8	78.5	76.6	68.7	56.7	41.5	27.2
11	30.8	29.5	43.3	54.6	65.2	79.3	81	79.5	72.2	60.7	45.1	31.1
12	34.9	32.5	46.7	56.8	67.1	81.6	83.1	81.4	74.8	63.9	48.4	35.1
13	38.2	35	49.4	59.3	68.4	83.1	84.8	83	76.8	65.8	50.9	38.7
14	41	37.1	51.3	61	69.4	84	86.2	84.1	78.3	67.2	52.8	40.8
15	42.5	38.5	52.7	62.4	70.8	84.8	87.2	84.8	79	67.9	54	42
16	42.5	39	53	63.2	71.6	85	87.3	84.9	79	68.1	54.1	42.5
17	41.6	38.6	53	63.1	71.9	84.9	86.8	84.6	78.4	67	52.8	40.8
18	38.1	37.2	51.7	62.4	70.9	84	85.9	83.2	76.3	64.2	49.5	37
19	34.2	34.6	49.1	60.1	69.3	82.5	83.9	80.5	72.3	59.9	46.6	34.4
20	31.8	32.9	46.3	56.8	65.6	79.5	80.7	76.8	68.5	57.1	44.8	32.3
21	30.1	31.6	44.4	54.4	62.5	76	77.4	73.9	66.6	55.5	43.4	30.6
22	29.2	30.8	42.6	52.8	60.2	73.9	75.8	72.1	65.2	54.1	42.2	28.4
23	27.9	29.5	41.7	51	58.4	72.4	74.4	70.8	64.1	52.9	41.1	27
24	26.8	28.8	40	49.6	57.2	71.2	73	69.8	63.1	51.7	39.9	25.3

Table 22 Average Monthly Percent Relative Humidity by Hour of the Day for St. Louis County

	MonthID											
HourID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	67.3	75.9	71.8	70	75.9	75.8	82.3	85	87.4	75.9	68.9	70.2
2	68.1	77.1	72.2	72.6	76	78.1	83.3	85.8	87.7	77.6	70.3	71.8
3	69.5	78.3	73.3	74.2	77.4	80	84.2	86.7	88.6	79.1	71.7	72.9
4	70.3	78.5	74.4	74.7	78.5	81.3	84.7	87	89.5	79.6	72.5	73.8
5	71.5	78.5	75.9	75.6	79.3	82.4	85.9	87.9	89.8	81.1	73.6	75.7
6	72	78.8	77.7	76.1	80.5	83.3	86.2	88.4	90.1	82	75.4	76.4
7	71.7	79.1	78	76.4	79.4	81.1	84.7	88.2	90.1	82.9	76.3	76.7
8	71.4	78.4	78.6	72.5	75	75.6	79.8	83.2	88.6	82.4	76.6	76.6
9	70.3	77.2	74.8	67.9	71	70	73.4	76.3	83.3	76.7	74.1	75.2
10	66	74.2	69.9	63.7	65	64.7	67.9	68.6	76.2	67.6	68.2	72.7
11	61.4	70.5	64.6	60.2	60	60	63.2	62.8	69.1	59.4	62.3	68.9
12	56.7	67.1	59.6	57.8	57.5	55.2	59.2	58.4	63.5	53.1	57.5	66
13	52.8	64.6	56	54.9	56.4	52.3	56.3	55.8	59.6	49.5	53.4	63.2
14	49.8	62	53.9	53.1	55.1	51.3	54.2	53.9	57	47.2	50.4	61.2
15	47.8	59.9	52.4	51.3	53.5	49.5	52.5	52.9	55.5	45.9	48.4	59.9
16	46.8	59	52.7	49.9	52.7	48.6	52.5	52.9	55.3	45.5	47.5	59.2
17	47.2	59.7	52.9	49.6	51.4	48.6	53.2	53.9	56.8	46.6	48.8	60.5
18	50.6	61.2	54.8	50.5	51.4	49.7	54.7	56.4	61.5	51.4	53.2	64.1
19	55.1	65.1	58.5	54	53.5	52.4	58.9	62	70.6	59.1	57.2	66.5
20	58.2	68.2	62.5	58.2	59	57.9	65.8	69.8	78.6	65.1	60	67.9
21	60.2	70.4	65.3	61.4	64.5	64.3	72.3	76.1	82.2	68.2	62.1	68.3
22	61.9	72.1	67.7	63.6	69.2	69	75.5	80	84.2	70.4	64	68.6
23	63.7	73.8	69.3	66.6	72.5	71.6	77.7	82.2	85.3	72.5	65.7	69
24	65.2	75	71.1	68.3	74.6	74.3	80.1	83.9	86.5	74.6	67.4	69.7

Table 23 Average Monthly Temperatures by Hour of the Day for St. Louis City in Fahrenheit

	MonthID											
HourID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	25.9	28.9	40.2	48.1	56	70.1	72.4	69.2	62.7	51.5	39.4	25.9
2	25	27.5	38.4	46.2	54.9	69.1	71.2	68.5	62.9	50.7	39.2	25.9
3	24	26.3	37.4	45.3	53.8	68	70.6	67.7	62.2	49.9	38.3	25
4	22.9	25.4	36.3	44.3	52.9	67	70.1	67	61.5	49.4	37.8	24.6
5	22.4	24.9	35.6	43.7	52.2	66.2	69.6	66.3	61	48.6	37.1	23.9
6	21.7	24.4	34.5	43.4	51.8	65.6	69.1	65.9	60.6	47.9	36.4	23.9
7	21.5	23.8	33.9	43.7	53.6	67.9	70.6	66.5	60.5	47.5	35.8	23.9
8	21.3	23.5	34.2	46	57	71.2	73.5	70.2	62.6	48.8	35.8	23.2
9	22.8	24.9	37.7	49.2	59.8	74.4	76.5	73.7	66	53.3	38.7	25.2
10	27	27.5	41	52.1	62.9	77.4	79.2	77.5	69.5	57.8	42.5	28.4
11	31	30.3	44.3	54.8	65.6	79.9	81.6	80.3	72.9	61.8	45.9	32
12	35	33	47.4	57	67.7	82.1	83.6	82.3	75.4	64.8	49.3	35.9
13	38.1	35.5	50.1	59.3	68.7	83.8	85.2	83.7	77.3	66.8	51.7	39.3
14	41.1	37.4	51.8	61	69.7	84.5	86.7	84.9	78.7	68.1	53.5	41.5
15	42.7	38.8	53.3	62.4	71.1	85.3	87.6	85.5	79.4	68.8	54.6	42.9
16	42.5	39.3	53.6	63.2	71.7	85.4	87.8	85.5	79.5	68.8	54.6	42.9
17	41.6	39.1	53.4	62.9	72	85.4	87.5	85.3	78.7	67.9	53.3	41.5
18	38.1	37.7	52.2	62.1	71.2	84.4	86.4	83.8	76.8	65.1	50	37.7
19	34.3	35.1	49.5	60.1	69.4	82.9	84.5	81.2	72.5	60.7	47.2	35
20	32.1	33.4	47	56.7	65.8	79.8	81.4	77.2	68.5	57.8	45.2	33.4
21	30.4	32.2	45	54.5	62.5	76	77.9	74.3	66.8	56.2	43.8	31.6
22	29.5	31.3	43.5	52.8	60.2	73.6	76.2	72.3	65.5	54.9	42.7	29.8
23	28.3	30.1	42.6	51	58.3	72.2	74.8	71.2	64.3	53.6	41.6	28.4
24	27.2	29.6	41.1	49.5	57.1	71	73.6	70.3	63.4	52.4	40.6	26.8

Table 24 Average Monthly Percent Relative Humidity by Hour of the Day for St. Louis City

	MonthID											
HourID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	68	76.6	72.6	71.4	77	76.6	83.4	85.9	87.7	76.9	69.3	69.8
2	69	78.1	73.2	73.8	76.9	78.7	84.2	86.5	87.7	78	71	71.3
3	69.8	79	74	74.8	78	80.8	85.4	87	88	79.7	72.1	72.7
4	70.9	79	75.2	75.9	79.1	81.9	85.6	87.6	88.9	80.3	72.3	73.6
5	72.1	78.9	76.3	76.5	79.9	82.7	86.5	88.5	89.5	81.5	73.4	75.2
6	72.4	79.2	78.4	77.4	80.5	83.9	86.8	88.5	89.8	82.7	75.2	75.8
7	72.7	79.5	79	77.1	79.4	81.7	85.1	88.2	89.5	83.3	76.3	76.2
8	72.3	79.1	79.4	73.4	75.1	75.9	80.1	83.3	88.3	83.1	76.3	76.4
9	70.9	77.9	75.6	68.3	71	70	74	76.4	83	77	73.6	75
10	66.7	74.9	70.6	64.2	64.8	64.5	68.4	68.9	75.7	67.4	68	72.5
11	61.9	71.5	65.5	60.7	60.1	59.6	63.7	63.1	68.9	59.1	62.4	69
12	57.4	68.3	60.7	58.5	57.1	55.3	59.7	58.7	63.6	52.8	57.2	66.1
13	53.7	65.5	57	55.7	56.4	52	57.1	56.3	59.7	48.9	53.8	63.1
14	50.6	63.3	55.1	53.7	55.1	51.2	54.6	54.2	57	46.4	50.7	61.1
15	48.4	61.4	53.4	51.7	53.7	49.5	53.1	53.5	55.5	45.5	48.5	59.5
16	47.8	60.3	53.4	50.4	52.9	48.9	52.7	53.5	55.1	45.3	47.8	59.1
17	48	60.7	53.8	50.2	51.8	48.9	53.4	54.2	56.8	46.4	48.9	60.1
18	51.2	62.1	55.8	51.4	51.4	49.9	55.2	57.1	61.6	51.3	53.3	63.6
19	55.9	66	59.7	54.8	53.9	52.4	59.2	62.6	71.1	59.4	57.3	66.2
20	58.7	69.2	63.6	59.6	59.7	58.2	66.3	71.1	79.7	65.7	60.6	67.5
21	60.8	71.1	66.4	62.1	65.5	65	73.6	77.5	83.4	68.8	62.6	68.4
22	62.5	73.1	68.7	64.8	70	70.2	76.8	81.4	84.8	71	64.5	68.7
23	64.3	74.8	70.2	67.7	73.6	72.8	79.1	83.1	86.2	73.1	66.3	68.9
24	66.1	75.7	71.8	69.4	75.7	75.3	81	84.8	87.1	75.5	67.8	69.6

3.3.2.3 On Road Source Emissions Summary

The MOVES model runs were set up selecting all available gasoline and diesel fuel vehicle type combinations, all months, days, hours, and all road types. The emissions were post-aggregated to the year level using MOVES.

A list of on road mobile emissions by county and SCC is included in Appendix A-2.

Table 25 summarizes the 2008 annual on-road emissions by county as calculated using MOVES 2010A for St. Louis City and St. Louis County.

Table 25 On Road Mobile 2008 CO Emissions for St. Louis City and St. Louis County

County Name	CO Emissions (tons/year)
St. Louis County	132,855.83
St. Louis City	34,576.81
Totals	**167,432.64**

4.0 Quality Assurance/Quality Control

4.1 Point Source QA/QC and Results

Prioritization

The EI Unit prioritizes review of those facilities that have the largest bulk emissions, specifically facilities with a Part 70 or Intermediate operating permit. While every data element collected helps to characterize the emission estimate, in evaluating the data, those fields most directly tied to the emissions calculation are given the highest priority. The MoEIS database system itself was quality assured to provide smooth data transfer from the state inventory to the NEI.

Methods

The EI Unit's general QA procedures utilize any and all of the techniques outlined in the EPA's Emission Inventory Improvement Program (EIIP) Technical Report Series Volume 6: Quality Assurance Procedures. The unit groups these techniques into two basic categories: Phase I, or Bottom-Up QA procedures, and Phase II, or Top-Down QA procedures. Top-Down Procedures analyze groups of emissions data that share a common trait and look for outliers, in keeping with the 'Reality Check' technique. Bottom-Up Procedures evaluate individual EIQs that are believed to be erroneous, whether due to a top-down analysis, errors found when entering the EIQ into the database, or inconsistencies brought to the attention of the EI Unit by a third party. These bottom-up procedures utilize the 'Peer Review', the 'Sample Calculations', or the 'Independent Audit' techniques. Note that any of these techniques could be found in either category; they have simply been mentioned in reference to the category in which they are most often found.

Quality checks are completed using computerized checks in the MoEIS automated system, exploiting its utility in ensuring that the necessary data is reported, and in providing an acceptable numeric range for certain fields. It streamlines the process of ensuring that all data fields required for the EPA's EIS system are present, are compatible with, and meet the needs of the EPA system. For example, emission release point records that were missing fields were corrected with the input of emission modelers and facility staff. Outdated Source Classification Codes (SCC), units of measure, and control device codes were removed, and required data fields for stack emission release points were added.

Phase I reviews address individual EIQs to reconcile discrepancies with emission data. Phase I reviews are generally done only on hardcopy submitted EIQs, but may also be done based on priority. Examples of EIQ issues that were encountered include throughputs and emission factors with inconsistent units of measure, emission unit identifiers that are different from previous EIQs, and MoEIS-calculated emissions that differ from the emissions on the hardcopy forms. Technical staff conducting these reviews worked with the companies to make corrections to their EIQs and place written documentation of all changes in the hardcopy EIQ files stored in the fileroom. In addition, all changes made to EIQs are tracked in an electronic log file.

Phase II reviews take a top-down look at the emissions data. This phase involves running Access queries to identify potential issues to investigate further. The Phase II QA queries included ensuring condensable particulate emissions were reported, ensuring correct application of sulfur/ash content in emission factors, and reviewing emission trends by facility and industry type to identify any anomalies. In addition, point source data from other databases incorporated by the EPA into the EIS, such as the Toxics Release Inventory (TRI) and the Clean Air Markets Division (CAMD), will be reviewed and compared to MoEIS data. Prioritization of the largest sources, largest changes, and largest anomalies is a top consideration, as is realizing a meaningful emission difference within a reasonable amount of time. Any changes made to EIQs during the Phase II QA process will be done with input from the companies, and written documentation of all changes will be placed in the EIQ files stored in the fileroom and in electronic files.

Results

Interannual Variability- Facilities that reported over 20 tons of chargeable emissions were examined to find sources with large interannual variability. A list of 20 facilities was generated where plantwide chargeable emissions changed by more than 20%, and each of these facilities were contacted to verify the source of the increase or decrease. Four facilities reported an emission change due to emission factor or control device changes, and the other 16 facilities reported throughput changes were the cause of the emission differences. Since the cause of the emission variability has been documented, there is no cause for changes to the emissions report for these twenty facilities.

Local Agency QA – Four facilities in St. Louis City were selected for a detailed audit based on their level of emissions and variation from past year reporting. At the four facilities, over 20 emission units were audited to confirm throughput, appropriate emission factor use, appropriate control efficiency application, permitted equipment limits, and number of pollutants. Six emission units were found to be incorrectly reported in the 2008 emission report, with one facility having overreported almost 10 tons of PM_{10}, and another underreported 40 tons facility-wide. Phase 1 quality assurance steps were used on 14 facilities in Springfield, 7 facilities in St. Louis County, and twenty facilities in Kansas City. Throughputs, emission factors, incorrect calculations, and HAP reporting were reviewed for these sites.

Stack Parameters – In preparation for point source data submission to the NEI, the required data elements for stack emission release points were queried to ensure the data submittal could occur without errors. Of the over 2,600 stack release points associated with point source emission reports that are submitted to the 2008 NEI, almost 50% required quality assurance before they could be submitted. Three main quality assurance steps were taken to correct the stack data: missing data elements were filled in as possible, data elements that were out of range were quality assured, and previously submitted NEI data elements were compared to current Missouri emission report data to identify discrepancies. Filling in missing data elements took the most time because it required review of modeling files, contact with local agency staff, or contact with the facility. Out of range data elements were a much smaller portion of the quality assurance, but these were also corrected via modeling files and contact with the facility. Discrepancies between the EIS and 2008 Missouri EIQ data were reconciled by accepting the Missouri data instead of EIS data.

4.2 Nonpoint Source QA/QC

EI Unit staff has documented the following information for each nonpoint source category: source of data for activity, emission factors, allocation methodologies, nonpoint source SCCs covered, pollutants covered, and point source subtraction in Table . Much of the documentation for EPA categories appears at the NEI website: http://www.epa.gov/ttn/chief/net/2008inventory.html

Emission inventory staff participated in the ERTAC workgroup that developed many of the updated emission factors and methodologies used for 2008 emission estimates, and the resulting emission factors were checked against those used in EPA templates for accuracy. All nonpoint source categories in the 2008 NEI will be reviewed, including those for which EPA is developing emissions estimates. The emission estimates were compared to the 2005 NEI to identify outlying or missing categories.

Quality checks of the EPA excel worksheets showed that three worksheets had incorrect emission factors when compared to the ERTAC summary emission factor page, and these were corrected before emissions were submitted. Several categories had spreadsheet templates that omitted HAP calculations, and these were amended prior to completing the categories. Spot checks were also done on the calculation pages to ensure formulas were followed, and no problems were found.

Quality assurance of the data included checks against 2002 NEI data submissions, and completeness checks for the number of counties, number of pollutants, order of magnitude, and correct units of measure. The priority data checks showed no errors, but there are a few source categories included in the 2002 NEI that were not included in the 2008 NEI due to time constraints (see section 3.2).

4.3 Mobile Source QA/QC

4.3.1 Nonroad Source QA/QC

Quality control and quality assurance were conducted throughout the nonroad modeling process.   Data collected from various data sources were verified and correctly entered or transcribed into the model.   In some instances, input values, i.e., temperatures and fuel values were double and/or triple checked for accuracy to insure they corresponded to Missouri DNR data. In addition, a spot-checking of the modeling results, including rerunning the model for those results in question, was performed to ensure reliability.

4.3.2 Onroad Source QA/QC

The data used for the modeling was originally collected for creating the 2008 NEI. Missouri DNR has conducted extensive quality assurance on the model inputs and the inputs have been reviewed by EPA. The inputs were converted to MOVES formatting using EPA conversion tools. The MOVES converted data was double and/or triple checked to ensure accuracy. In addition, a spot-checking of the modeling results, including rerunning the model for those results in question, was performed to ensure reliability.

Appendix A-1

List of Statewide Point Source CO Emissions by Facility

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Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Amerenue-Kirksville Combustion Turbine	29001	0006	221112	0.05
Keller Construction Company-Keller Construction Company	29003	P011	324121	8.66
Archer Daniels Midland Co-Mexico Plant	29007	0002	311222	19.79
Harbison-Walker Refractories-Vandalia Plant	29007	0003	327124	20.69
Amerenue-Mexico Combustion Turbine	29007	0012	221112	0.11
Martinsburg Farmers Elevator-Martinsburg	29007	0033	42451	
Teva Pharmaceuticals Usa Inc-Mexico	29007	0040	325412	0.51
VANDALIA POWER PLANT-VANDALIA	29007	0041	221112	0.08
Cerro Copper Casting Company-Cerro Copper Casting Company	29007	0047	331525	144.61
Mexico Plastic Company-Mexico	29007	0051	326111	0.07
Audrain Generating Station	29007	0053	221112	10.66
POET BIOREFINING-LADDONIA PLANT	29007	0054	325193	41.29
Efco Corporation-Efco Corporation	29009	0003	332321	4.34
Hydro Aluminum Wells-Monett	29009	0005	331421	14.26
SCHREIBER FOODS INC-SCHREIBER FOODS INC - MONETT	29009	0021	311513	10.99
Fasco Industries Inc-Cassville Plant	29009	0037	335312	1.23
Justin Boot Company-Cassville (Plant 414)	29009	0052	316213	0.14
ARCHITECTURAL SYSTEMS INC-MONETT	29009	0062	332321	
GEORGE'S INC-POULTRY FEED MILL	29009	0066	311119	0.21
Lamar City Electrical Generation-Lamar	29011	0031	221112	0.20
BFI Waste Systems Of North America Inc-Lamar Landfill & Prairie View Reg Waste	29011	0039	562212	125.44
Butler Municipal Power Plant-Butler	29013	0029	221112	0.08
CONTINENTAL COAL INC-COTTONWOOD CREEK MINE	29013	0036	212111	1.50
Natural Gas Pipeline Company-Marble Hill Plant	29017	0019	48621	161.20
Columbia Municipal Power Plant-Columbia	29019	0002	221112	137.00
University Of Missouri - Columbia-Power Plant	29019	0004	221112	681.51
Magellan Pipeline Company Llc-Columbia Station	29019	0005	48691	9.25
A B Chance Co-Allen Street Complex	29019	0039	335313	5.05
Christian Health Systems-Boone Hospital Center	29019	0045	62211	1.70
University Of Missouri - Columbia-Main Campus Sources	29019	0047	62211	-
Torque Traction Integration Technologies-Columbia	29019	0066	336211	0.35
Panhandle Eastern Pipeline-Centralia Compressor Station	29019	0077	48621	232.05
Columbia Sanitary Landfill-Columbia Sanitary Landfill	29019	0091	562212	76.16
Ameren Energy Generating Company-Columbia Energy Center	29019	0105	221112	0.37
Aquila Inc-Lake Road Plant	29021	0004	221112	165.26
Life Line Foods-St Joseph	29021	0016	311211	22.39
Albaugh Inc-Albaugh Inc	29021	0037	32532	
Omnium Llc-St Joseph	29021	0045	32532	-
Weyerhaeuser-St Joseph	29021	0046	322211	4.25
Bartlett Grain Company Lp-St Joseph	29021	0056	42451	
Ag Processing Inc-St Joseph - Lower Lake Road	29021	0060	311222	1.53
Heartland Regional Medical Center East-St Joseph	29021	0063	62211	4.25

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Silgan Containers Corp-Silgan Containers	29021	0064	332431	5.42
Altec Industries Inc-Altec Industries Inc	29021	0078	33312	1.95
Varco-Pruden Buildings-St Joseph	29021	0095	332311	-
St Joseph Landfill-St Joseph Landfill	29021	0105	562212	15.08
AG PROCESSING-ST. JOSEPH BIODIESEL	29021	0118	325199	
Williamsville Materials-Poplar Bluff	29023	0003	212321	
Pace Construction Co-Poplar Bluff Plant	29023	0021	324121	0.07
John J Pershing Va Medical Center-Poplar Bluff	29023	0027	62211	1.23
Gates Rubber Company-Poplar Bluff Division	29023	0032	32622	3.51
Briggs & Stratton Corp-Poplar Bluff	29023	0038	333618	30.85
Centerpoint Energy-Poplar Bluff Compressor Station	29023	0042	48621	130.90
Poplar Bluff Municipal Utilities-Generating Plant	29023	0050	221112	3.61
Butler County Sanitary Landfill-Allied Waste Industries	29023	0058	562212	50.51
Nordyne-Poplar Bluff	29023	0062	333415	0.01
Consumers Oil And Supply Company-Braymer Plant	29025	0008	42451	
Harbison-Walker Refractories-Harbison-Walker Refractories	29027	0001	327124	5.08
Fulton Power Plant-Fulton	29027	0007	221112	1.29
A P Green Industries Inc-Fulton Plant	29027	0010	327124	31.57
ABB Inc-Jefferson City Plant	29027	0019	335311	4.16
Fulton State Hospital-Fulton	29027	0021	62221	5.51
Amerenue-Callaway Nuclear Power Plant	29027	0026	221113	4.34
Modine Manufacturing Co-Modine Manufacturing Co	29029	0009	333415	1.61
Delta Asphalt Inc-Cape Girardeau	29031	0002	324121	37.21
Martin Marietta Materials-Appleton Quarry #368	29031	0008	212312	-
Southeast Missouri State University-Facilities Management	29031	0010	61131	33.90
Ceramo Co Inc-Jackson	29031	0012	327112	3.48
Lone Star Industries Inc-Cape Girardeau	29031	0021	32731	8,359.89
Procter & Gamble Paper Products Co-Neely'S Landing	29031	0053	322291	266.04
St Francis Medical Center-Cape Girardeau	29031	0058	62211	4.24
Jackson Municipal Utilities-Jackson Municipal Utilities	29031	0061	221112	0.12
Biokyowa Inc-Nash Road Site	29031	0064	325411	19.76
Nordenia U S A Inc-Neely'S Landing	29031	0072	31213	-
Consolidated Grain And Barge Co-Cape Girardeau	29031	0081	42451	
Sinclair Oil Corp-Carrollton Station	29033	0001	48691	3.18
Agriservices Of Brunswick Llc-Brunswick West	29033	0013	42451	-
Carrollton Municipal Utilities	29033	0022	221112	0.71
Ray-Carroll County Grain Growers Inc-Carrollton Facility	29033	0023	42451	0.20
SHOW ME ETHANOL LLC-CARROLLTON	29033	0036	325193	-
Martin Marietta-Greenwood Quarry #527	29037	0001	212312	
Martin Marietta-Peculiar Quarry #528	29037	0002	212312	
Aquila Inc-Ralph Green Generating Plant	29037	0003	221112	0.53
Southern Star Central Gas Pipeline-Peculiar Compressor Station	29037	0048	48621	6.58
Aries Power Plant-Pleasant Hill	29037	0056	221112	46.47

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
KCP&L GMO-SOUTH HARPER PEAKING FACILITY	29037	0063	221112	56.06
Dairiconcepts-El Dorado Springs	29039	0003	311514	8.20
Salisbury Station Platte Pipe Line Co-Salisbury	29041	0013	42472	
National Starch & Chemical Co-National Starch & Chemical Co	29047	0002	311221	28.73
Archer Daniels Midland Co-ADM Milling Co	29047	0009	311211	0.59
Cook Composites And Polymers Co-North Kansas City	29047	0012	325510	5.19
Ford Motor Co-Kansas City Assembly Plant	29047	0019	336111	57.08
Bartlett Grain Company-Birmingham	29047	0025	42451	
Cargill Inc-Chouteau Elevator	29047	0027	42451	
Henry Wurst Inc-North Kansas City	29047	0032	323110	0.07
Midland Lithography Co-North Kansas City	29047	0033	323110	-
Davis Paint Co-Davis Paint Co	29047	0040	32551	-
Jesco Resources Inc-Jesco Resources Inc	29047	0052	324191	0.15
Hallmark Cards Inc-Distribution Center	29047	0059	323110	1.62
Tnemec Company Inc-Tnemec Company Inc	29047	0075	32551	
Campbell Earl Mfg Co-Campbell Earl Mfg Co	29047	0079	32551	
Independence Power And Light-Missouri City Station	29047	0096	221112	8.85
Banta Publications-Kansas City	29047	0122	336211	1.50
Sericol Inc-Sericol Inc	29047	0141	32591	0.07
Vertex Plastics Inc-Kearney	29047	0175	326191	
Water Supply Division-Kansas City	29047	2227	22131	1.62
United Cooperative Inc-Plattsburg Elevator	29049	0016	42472	-
Amerenue-Moreau Combustion Turbine	29051	0008	221112	0.13
Unilever Hpc Usa-Jefferson City Plant	29051	0009	325611	3.21
Von Hoffman Press Inc-Jefferson City	29051	0028	323117	
Modine Manufacturing Company-Jefferson City	29051	0032	336211	2.06
Johnson Controls Hoover Auto-Johnson Controls Hoover Auto	29051	0037	32614	-
Phillips Pipeline Company-Jefferson City Terminal	29051	0042	42471	32.25
Command Web Offset Missouri Inc-Jefferson City	29051	0043	323110	4.51
Amerenue-Fairgrounds Combustion Turbine	29051	0049	221112	0.25
Jefferson City Landfill-Laidlaw Waste Systems	29051	0058	562212	70.46
W R Meadows Inc-Boonville	29053	0003	321219	70.39
Caterpillar Inc-Caterpillar Inc	29053	0019	326291	1.80
Nordyne Inc-Boonville Plant	29053	0021	333414	0.74
Missouri Dept Of Corrections-Boonville Correctional Center	29053	0027	92214	2.67
Paramount Metalizing Co-Sullivan	29055	0043	32622	
Landmark Mfg Corp-Landmark Mfg Corp	29061	0010	332313	1.34
Magellan Pipeline Company Llc-Osborn Station	29063	0009	48691	3.86
United Cooperative Inc-Osborn Elevator	29063	0013	42451	
Royal Oak Enterprises Inc-Salem Briquet Plant	29065	0038	325191	38.34
White Oak Gin Company Inc-White Oak Gin Company Inc	29069	0010	115111	1.02
Graves Kennett Gin-Kennett	29069	0014	115111	0.13
Farmers Union Gin-Farmers Union Gin	29069	0018	115111	

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Four Way Gin Company-Four Way Gin Company	29069	0027	115111	
Cardwell Cooperative Inc-Cardwell Cooperative Inc	29069	0029	115111	
Stokes Mayberry Gin Company-Stokes Mayberry Gin Company	29069	0032	115111	-
Kennett Generating Plant	29069	0063	221112	0.97
Campbell Municipal Power Plant	29069	0064	221112	0.20
Associated Electric Cooperative Inc-St Francis Power Plant	29069	0066	221112	30.23
Amerenue-Labadie Plant	29071	0003	221112	2,494.33
Canam Steel Corp-Canam Steel Corp	29071	0014	332312	0.14
Steelweld Equipment Co-St Clair	29071	0020	336211	0.17
Jefferson Smurfit Corp-Pacific	29071	0031	322212	-
Meramec Industries Inc-Ramsey St Plant	29071	0068	326121	0.06
Bull Moose Tube Company-Bull Moose Tube Company	29071	0087	33121	0.32
Sullivan Precision Metal Finishing Inc-Sullivan Precision Metal Finishing Inc	29071	0131	332813	-
Sporlan Valve Company-Plant #2 - West Main	29071	0132	332911	
Integram - St Louis Seating-Pacific	29071	0144	33636	0.48
Aerofil Technology Inc-Aerofil Technology Inc	29071	0151	311942	0.39
Magnet Llc-Washington	29071	0153	33995	
Marble Decor Inc-Marble Decor Inc	29071	0154	326121	-
Plaze Incorporated-Plaze Incorporated	29071	0157	311942	0.35
GDX Automotive - Danny Scott Drive-New Haven	29071	0173	31332	
Sporlan Valve Company-Plant #3 - Lange Drive	29071	0178	332919	
RR Donnelley-Owensville	29073	0008	323110	1.58
Carlisle Power Transmission Products Inc-Springfield	29077	0004	326220	5.97
James River Power Plant	29077	0005	221112	1,195.87
Bristol Manufacturing Corp-Bristol Manufacturing Corp	29077	0008	311513	0.91
Aarons Automotive Products Inc-Westgate Ave Facility	29077	0010	336211	192.96
Interstate Brands Corporation-Butternut Bread	29077	0011	311812	0.75
Clariant Life Science Molecules-Clariant Life Science Molecules	29077	0017	325411	1.79
Sweetheart Cup-Sweetheart Cup	29077	0021	322215	2.11
Kraft Foods North America Inc-Kraft Foods North America Inc	29077	0026	311513	9.33
St John'S Regional Health Center-Springfield	29077	0028	62211	16.38
Dairy Farmers Of America Inc-Springfield	29077	0036	311514	7.82
Southwest Power Plant	29077	0039	221112	154.05
Southwest Mo State Univ-Physical Plant	29077	0047	61131	6.15
3M Company-Springfield ITSD/TMD	29077	0051	32552	6.00
General Electric-Springfield	29077	0056	335312	0.84
Magellan Pipeline Company Llc-Springfield Terminal	29077	0116	48691	17.94
City Utilities Of Springfield-Main Avenue Gas Turbine	29077	0145	221112	0.02
Springfield Sanitary Landfill-Willard	29077	0161	562212	90.80
City Utilities Of Springfield-Fulbright Treatment Plant	29077	0163	92613	0.09
N L McCartney Dist Generation	29077	0164	221112	21.29
CITY UTILITIES OF SPRINGFIELD MISSOURI-NOBLE HILL LANDFILL RENEW ENGY CTR	29077	0170	221119	97.45

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Trinity Industries Inc-Trinity Industries Inc	29077	0200	48711	-
Superior Solvents & Chemicals-Superior Solvents & Chemicals	29077	0228	42469	
Modine Manufacturing Company-Trenton	29079	0004	336211	3.32
Trenton Municipal Utilities-Trenton Peaking Plant	29079	0027	221112	0.37
Magellan Pipeline Company Llc-Ridgeway Station	29081	0010	48691	19.60
Montrose Generating Station	29083	0001	221112	517.37
Tracker Marine-Clinton Plant	29083	0031	336612	2.03
Schreiber Foods Inc-Packaging Converting Plant	29083	0033	322221	0.54
Exide Technologies-Canon Hollow	29087	0001	331314	3.47
Golden Triangle Energy-Craig	29087	0016	32511	4.07
Smith Flooring Company-Mountain View	29091	0005	321918	30.17
Systems & Electronics Inc-West Plains	29091	0011	336212	0.15
Garnett Wood Products-Charcoal Plant	29091	0038	325191	982.05
Bruce Hardwood Floors-Bruce Hardwood Floors	29091	0046	321113	22.44
West Plains City Power Station	29091	0068	221112	0.01
Doe Run Company-Buick Mill	29093	0005	212231	-
Doe Run Company-Glover Smelter	29093	0008	331419	0.01
Doe Run Company-Buick Smelter	29093	0009	331419	13,390.57
Bp Products North America Inc-Sugar Creek Terminal	29095	0002	32411	1.07
U S Dept Of Energy-Kansas City Plant (Alliedsignal)	29095	0005	33422	1.07
Bayer Cropscience-Kansas City	29095	0011	32532	25.81
Clay & Bailey Mfg Co-Clay & Bailey Mfg Co	29095	0012	331511	0.05
Folgers Coffee Co-Folgers Coffee Co	29095	0017	31192	331.48
Trigen Energy Corporation-Grand Avenue Station	29095	0021	221112	34.41
Hawthorn Station	29095	0022	221112	2,406.55
Kansas City Power & Light Co-Northeast Station	29095	0023	221112	0.09
Wolcott & Lincoln Jackson Llc-Kansas City	29095	0026	42451	
Lafarge North America Inc-Independence Plant	29095	0030	32731	639.59
Aquila Inc-Sibley Generating Station	29095	0031	221112	370.96
Vance Brothers Inc-Vance Brothers Inc	29095	0037	324121	18.54
Blue River Treatment Plant-Blue River Treatment Plant	29095	0039	562211	28.33
Alliant Llc-Lake City Army Ammunition Plant	29095	0046	332992	26.59
Blue Valley Station	29095	0050	221112	53.07
Koch Materials Company-Koch Materials Company	29095	0064	324121	0.40
Independence Regional Health Center-Independence	29095	0066	62211	0.98
Peterson Mfg Co-Grandview	29095	0075	336321	0.51
Barber & Sons Aggregates-Barber & Sons Aggregates	29095	0076	212312	10.24
Hallmark Cards-Hallmark Cards	29095	0114	323110	3.07
Aquila Inc-Greenwood Energy Center	29095	0139	221112	14.18
Ball Metal Beverage Container Co -Kansas City	29095	0175	332431	6.72
Unilever Bestfoods North America-Unilever Bestfoods North America	29095	0178	311421	8.74
Aero Transportation Products Inc-Independence Plant	29095	0191	336211	
Independence Power And Light-Sub Station I	29095	0222	221112	0.07

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Independence Power And Light-Sub Station H	29095	0223	221112	0.55
Independence Power And Light-Sub Station J	29095	0224	221112	0.03
Tiffany Marble Inc-Lee'S Summit	29095	0244	326121	-
Courtney Ridge Landfill Llc-Courtney Ridge Landfill Llc	29095	0267	562212	129.38
Lee'S Summit Sanitary Landfill-Lee'S Summit Sanitary Landfill	29095	0272	562212	37.96
Rumble Recycling And Disposal-Sanitary Landfill Rumble 1 & 2	29095	0273	562212	22.83
LAFARGE NORTH AMERICA INC-COURTNEY RIDGE QUARRY	29095	0321	212312	
Cargill Inc-Kansas City	29095	2001	311222	1.82
Crown Center Redevelopment Corporation-Kansas City	29095	2007	72111	9.65
Research Medical Center-Research Medical Center	29095	2054	62211	2.40
Cook Brothers Insulation Inc-Cook Brothers Insulation Inc	29095	2058	32614	-
Baptist Medical Center-Baptist Medical Center	29095	2087	62211	0.88
Allied Waste Industries Sanitary Landfil-Kansas City Landfill	29095	2101	562212	66.75
Truman Medical Center - East-Truman Medical Center - East	29095	2154	62211	0.04
International Paper Company-International Paper Company	29095	2177	322211	2.62
New Surface Llc-East 12th	29095	2224	327991	0.00
SUN CHEMICAL-KANSAS CITY	29095	2431	325910	
Empire District Electric Co-Asbury Plant	29097	0001	221112	195.75
Dyno Nobel Inc-Carthage Plant	29097	0007	32592	5.49
ADM Milling Company-Carthage Flour Mill	29097	0011	311211	0.07
Tamko Roofing Products Inc-High St Plant	29097	0013	324122	8.14
St John'S Regional Medical Center-St John'S Regional Medical Center	29097	0021	62211	4.24
Justin Boot Company-Carthage (Plant 417)	29097	0058	316219	
Empire District Electric Co-Empire Energy Center	29097	0062	221112	6.01
Modine Manufacturing Company-Joplin	29097	0065	332313	0.43
Magellan Pipeline Company-Carthage Terminal	29097	0079	48691	2.36
Able Manufacturing & Assembly L L C -Schifferdecker	29097	0089	336211	
Tamko Roofing Products Inc-Rangeline Plant	29097	0094	324122	88.27
Able Manufacturing Corporation-7th Street	29097	0095	326121	
Empire District Electric Co-State Line Facility	29097	0104	221112	650.53
Carthage Water & Electric	29097	0110	221112	3.79
Eagle-Picher Technologies Llc-Federal Systems	29097	0117	335911	0.18
Pechiney Plastic Packaging Inc-Joplin Plant	29097	0132	323112	2.08
ICI Explosives Environmental Co-Joplin	29097	0138	562211	0.35
Leggett & Platt-Wire Mill - Carthage Central Ave	29097	0143	331222	12.67
DYNAMIC FINISHES - JOPLIN	29097	0154	333131	
Rc Cement Company Inc-River Cement Co - Selma Plant	29099	0002	32731	302.96
Doe Run Company-Herculaneum Smelter	29099	0003	331419	23.25
Union Pacific Railroad Co-Desoto Car Shop	29099	0011	336510	1.27
Trautman Quarry-Pevely	29099	0012	212312	
Dow Chemical Company The-Riverside Plant	29099	0014	325211	1.11
Amerenue-Rush Island Plant	29099	0016	221112	1,333.35
Metal Container Corporation-Arnold	29099	0044	332431	9.43

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Engineered Coil Company-D B A Marlo Coil	29099	0052	336611	0.02
Saint-Gobain Containers Llc-Pevely	29099	0068	327213	8.30
Bussen Quarries Inc-Antire Quarry	29099	0103	212312	
Carondelet Corporation-Carondelet Corporation	29099	0111	331513	4.14
Aero Metal Finishing-Aero Metal Finishing	29099	0114	332813	
Central Missouri State University-Physical Plant	29101	0002	61131	5.60
Stahl Specialty Co-Kingsville Plant	29101	0003	331524	10.16
Whiteman Air Force Base-Whiteman	29101	0009	92811	15.54
Hawker Energy Products Inc-Warrensburg	29101	0023	335912	2.72
Show-Me Regional Landfill-Show-Me Regional Landfill	29101	0046	562212	46.45
Holden Power Plant	29101	0051	221112	0.57
Master Marble Inc-Holden	29101	0054	326121	-
Independent Stave Co Inc-Lebanon Plant	29105	0001	321920	37.88
Lowe Boats-Omc Aluminum Boat Group	29105	0006	336612	0.16
Detroit Tool & Engineering-Lebanon	29105	0013	332212	
Marathon Electric Mfg Corp-Lebanon Plant	29105	0033	335312	0.28
G3 Boats-Lebanon	29105	0038	336612	
Tracker Marine-Lebanon Plant	29105	0046	336612	0.23
S & K Industries Inc-S & K Industries Inc B #1	29107	0004	337122	2.00
Wincup-Higginsville Plant	29107	0010	325211	5.40
S & K Industries Inc-S & K Industries Inc B #2	29107	0029	321912	
Higginsville Municipal Power Facility	29107	0038	221112	0.43
Bartlett Grain Company Lp-Waverly	29107	0050	42451	0.00
NEW SURFACE-ODESSA	29107	0063	326121	0.01
Razorback Pipeline Company-Transmontaigne Product Services Inc	29109	0002	49311	0.30
Bcp Ingredients-Verona Plant	29109	0004	325411	1.61
Mo Rehabilitation Center-Mo Rehabilitation Center	29109	0008	62211	1.06
ConocoPhillips Co-Mount Vernon Products Terminal	29109	0036	42471	18.78
E F Marsh Engineering Company-Mt Vernon	29109	0051	333922	
AYERS OIL CO-CANTON	29111	0019	424710	
Old Monroe Elevator & Supplies-Old Monroe	29113	0003	311119	0.04
Toyota Motor Corporate Services-Bodine Aluminum Inc	29113	0029	331524	4.70
Farmers Elevator & Supply Co-Hawk Point	29113	0042	42491	0.02
Most Inc-Troy	29113	0046	331314	1.46
Walsworth Publishing Company-Marceline	29115	0001	323110	0.04
Chillicothe Municipal Utilities	29117	0002	221112	0.22
Donaldson Co Inc-Donaldson Co Inc	29117	0012	336211	1.16
Simmons Foods Inc-Southwest City	29119	0017	311615	52.65
Superior Maple Hill Landfill-Macon	29121	0027	562212	41.59
Northeast Missouri Grain Llc-Macon	29121	0028	32511	66.39
MACON MUNICIPAL UTILITIES-NEMO GENERATING STATION	29121	0033	221112	12.02
MACON MUNICIPAL UTILITIES-KELLOGG AVE	29121	0035	221112	0.25
MACON MUNICIPAL UTILITIES-NOLL DRIVE	29121	0036	221112	0.12

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Centerpoint Energy-Twelve Mile Compressor Station	29123	0018	48621	194.01
Versa-Tech Inc-Fredericktown	29123	0022	32614	-
Kingsford Manufacturing Co-Briquetting Plant	29125	0001	325191	22.89
BASF Agri Chemicals-Hannibal Plant	29127	0001	32532	147.32
Magellan Pipeline Company Llc-Palmyra Station	29127	0002	48691	3.04
Fasco Industries Inc-Eldon Plant	29131	0032	335312	0.05
Gates Rubber Company-Gates Rubber Company	29133	0014	32622	0.92
Consolidated Grain And Barge Co-Dorena Facility	29133	0016	49313	-
Monroe City Power Plant-Monroe City	29137	0028	221112	0.04
Christy Minerals Co-High Hill	29139	0008	212324	82.34
Associated Electric Cooperative Inc-New Madrid Power Plant	29143	0004	221112	1,100.66
Noranda Aluminum Inc-Noranda Aluminum Inc	29143	0008	331312	24,770.83
Mahan Gin Co-Mahan Gin Co	29143	0012	115111	0.02
Portageville Farmers Gin Inc-Portageville Farmers Gin Inc	29143	0013	115111	
Plastene Supply Company-Div Siegel-Robert Inc	29143	0015	326121	0.65
Mccord Gin Company-Gideon	29143	0023	115111	-
Cargill Inc-New Madrid	29143	0027	325314	
A C Riley Cotton Company-New Madrid Gin	29143	0046	115111	
Bootheel Cotton Company Inc-Matthews	29143	0047	115111	-
Bunge North America Inc-Linda Elevator	29143	0062	42451	0.03
La-Z-Boy Chair Company-La-Z-Boy Midwest	29145	0005	337121	0.81
Fag Bearings Corporation-Joplin	29145	0007	332991	22.08
Premier Turbines-Neosho Plant	29145	0044	336412	12.45
Southern Star Central Gas Pipeline-Saginaw Compressor Station	29145	0049	48621	7.95
Northwest Missouri State University-Maryville	29147	0005	61131	57.07
Eveready Battery Co Inc-Maryville Plant	29147	0008	335912	1.90
Kawasaki Motors Mfg Corp-Kawasaki Motors Mfg Corp	29147	0023	333618	84.25
Anr Pipeline Company-Maitland Compressor Station	29147	0024	486210	236.82
Consumers Oil Co Inc-Maryville Plant	29147	0027	42451	
Nodaway Plant	29147	0032	221112	0.12
Central Electric Power Cooperative-Chamois Plant	29151	0002	221112	78.38
Quaker Window Products Company-Quaker Window Products Company	29151	0050	332321	0.56
L Berry Gin Company-L Berry Gin Company	29155	0021	115111	0.10
Still Gin & Grain Inc-Steele	29155	0024	115111	-
Trinity Marine Products Inc-Caruthersville - Plant #75	29155	0030	336611	0.50
Loxcreen Company Inc-Hayti	29155	0045	331316	3.53
Trinity Marine Products Inc-Caruthersville Plant #73	29155	0049	326121	0.12
Bunge North America Inc-Caruthersville Plant	29155	0063	42451	-
Tg Missouri-Perryville	29157	0019	336211	2.67
Falcon Foam-Falcon Foam	29157	0020	326121	2.28
H & G Marine Service Inc-Perryville	29157	0022	332439	
Tnt Plastics Inc-Perryville	29157	0027	326113	-
Martin Marietta Materials-Carolina Asphalt Company	29157	0032	324121	0.44

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Martin Marietta Materials Inc-Perryville Quarry #366	29157	P023	212312	
Lafarge North America Inc -Sedalia Quarry & Asphalt	29159	0002	212312	9.15
Pittsburgh-Corning Corp-Pittsburgh-Corning Corp	29159	0009	327993	22.34
Waterloo Industries Inc-Waterloo Industries Inc	29159	0012	332117	5.99
Alcan Cable-Div Of Alcan Products Corporation	29159	0022	331319	2.26
Hayes Lemmerz International Inc-Sedalia	29159	0027	336211	4.96
Tyson Foods Inc-Sedalia Processing Plant	29159	0037	311615	32.29
Gardner Denver Inc-Sedalia Plant	29159	0039	333912	-
Missouri Pressed Metals Inc-Sedalia	29159	0041	332117	0.00
Panhandle Eastern Pipe Line Co-Houstonia	29159	0047	48621	341.54
Edwards Fiberglass Inc-Sedalia	29159	0056	326191	
WEST CENTRAL CONCRETE LLC-SNOW RD	29159	0058	327320	-
EDWARDS FRP REPAIR-WINGATE	29159	0059	325211	
University Of Mo - Rolla-Rolla Power Plant	29161	0006	61131	23.79
Manchester Packaging Company-Manchester Packaging Company	29161	0039	326121	0.01
Rolla Municipal Utilities-Multiple Peaking Plants	29161	0054	221112	0.01
Holcim (Us) Inc-Clarksville	29163	0001	32731	1,734.85
Aqualon Div Of Hercules Inc-Missouri Chemical Works	29163	0002	32511	54.23
Wayne B Smith Inc-Wayne B Smith Inc	29163	0008	212312	0.03
Bunge North America Inc-Louisiana Plant	29163	0025	49313	0.11
Dyno Nobel Inc-Lomo Plant	29163	0031	325311	
Eagle Ridge Landfill-Bowling Green	29163	0040	562212	0.94
Amerenue-Peno Creek Energy Center	29163	0047	221112	2.18
American Airlines-Mci Maintenance And Engineering Base	29165	0005	336411	-
Kansas City Power & Light Co-Iatan Generating Station	29165	0007	221112	628.83
Package Service Co Llc-Package Service Co Llc	29165	0021	323112	-
Woodbridge Corporation-Kansas City Foam Div	29165	0028	32614	1.21
KCI Airport - KCMO Aviation Dept	29165	2404	488111	3.20
Harley Davidson Motor Company-Kansas City Plant	29165	2415	336991	6.42
FACILITY OPERATION SERVICES LLC-NW 112TH	29165	2424	221330	13.15
Tracker Marine-Bolivar Plant	29167	0028	336612	-
Manscen And Fort Leonard Wood-Manscen And Fort Leonard Wood	29169	0004	928110	9.45
Associated Electric Cooperative Inc-Unionville Power Station	29171	0015	221112	0.01
Continental Cement Company Inc-Ilasco Plant	29173	0001	32731	84.78
ENNIS PAINT INC-SAVERTON	29173	0021	325510	
Buckhorn Rubber Products Inc-Buckhorn Rubber Company Inc	29173	0037	32622	-
Associated Electric Cooperative Inc-Thomas Hill Energy Center-Power Division	29175	0001	221112	4,486.18
Amerenue-Moberly Combustion Turbine	29175	0010	221112	0.13
OFFICE OF ADMINISTRATION FMDC-MOBERLY CORRECTIONAL CENTER	29175	0034	922140	6.92
Wilson Trailer Sales Inc-Moberly	29175	0061	336212	0.21
Doe Run Company-Bunker (Fletcher Mine)	29179	0006	212231	-
Amerenue-Sioux Plant	29183	0001	221112	765.30

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Fred Weber Inc-O'Fallon Asphalt Plant	29183	0004	324121	15.54
Fred Weber Inc-O'Fallon Stone Plant	29183	0007	212312	
McDonnell Douglas Corp-Boeing Company	29183	0010	334413	2.15
St Joseph Health Center-St Joseph Health Center	29183	0019	62211	3.18
Memc Electronic Materials Inc-St Peters Plant	29183	0027	334416	10.07
General Motors-Wentzville Center	29183	0076	336111	101.51
O Fallon Casting Llc-O Fallon	29183	0077	331512	1.55
Woodbridge Corporation-St Peters	29183	0129	32614	-
Superior Home Products Inc-Superior Home Products Inc	29183	0131	326121	-
True Manufacturing Co-O'Fallon	29183	0184	333415	1.39
Mississippi Lime Company-Mississippi Lime Co	29186	0001	32741	11,815.05
Biltbest Windows Corp-Ste Genevieve	29186	0003	321911	0.49
Tower Rock Stone Co-Ste Genevieve	29186	0022	212312	
Centerpoint Energy-Ste Genevieve Compressor Station	29186	0024	48621	9.73
Chemical Lime Company-Ste Genevieve	29186	0035	32741	28.37
Lead Belt Materials Co Inc-Park Hills	29187	0001	212312	4.30
Vessell Mineral Products-Vessell Mineral Products	29187	0002	327124	32.06
Flat River Glass Co-Park Hills	29187	0017	327211	4.76
Playpower Lt Farmington Inc-Iron Mountain Forge Corp	29187	0041	337121	2.67
S-R Products-Farmington	29187	0048	336991	0.21
Base Rock Minerals Inc-Bonne Terre Plant	29187	0072	212312	1.70
FARMINGTON LIGHT & POWER-FARMINGTON	29187	0075	221112	0.10
Chrysler Assembly Plant 1-Fenton	29189	0002	336111	21.86
Amerenue-Meramec Plant	29189	0010	221112	3,811.99
Fred Weber Inc-North Stone	29189	0017	324121	
Fred Weber Inc-South Stone	29189	0019	324121	
Monsanto World Headquarters-Lindbergh Blvd	29189	0020	54171	10.33
U S Silica Company-Pacific	29189	0021	212322	3.51
Dana Corporation-Perfect Circle Division	29189	0025	336311	0.87
Pharmacia-Chesterfield Village	29189	0032	32511	14.82
Rockwood Pigments Na Inc-E Hoffmeister	29189	0035	325131	8.27
Washington University-Millbrook Blvd	29189	0042	61131	18.42
St Louis Post-Dispatch-Dunlap Ind Dr	29189	0057	51111	0.16
Sunnen Products Company-Maplewood	29189	0064	333512	1.01
St Louis Airport Authority-Lambert International Blvd	29189	0065	336212	9.38
Simpson Construction Materials Llc-West Lake Quarry & Material Co	29189	0111	212312	15.71
Energy Petroleum Company-Kienlen	29189	0141	42471	
Printpack Inc-Hazelwood Plant	29189	0208	322221	3.45
Metropolitan St Louis Sewer District-Lemay Waste Water Treatment Plant	29189	0217	22132	321.07
Nesco Container Corp-Fenton	29189	0226	332439	1.07
McDonnell Douglas Corp /Boeing Company-Lindbergh Plant	29189	0230	336411	20.96
Chrysler Corp-North Plant	29189	0231	336111	65.23

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
St Louis Lithographing Company-Heege Avenue	29189	0238	323110	
Multiplex Display Fixture-Fenton	29189	0242	337127	0.49
Bussen Quarries Inc-Bussen Road	29189	0275	212312	
Ruprecht Quarry-Paule Rd	29189	0276	212312	
BFI Missouri Pass Landfill-Maryland Heights	29189	0281	562212	30.58
Color Art Inc-Crestwood	29189	0282	323110	1.01
Fred Weber Inc Sanitary Landfill-St Louis County	29189	0308	562212	130.13
Onyx Oak Ridge Landfill Inc-(West County)	29189	0310	562212	44.89
Bridgeton Landfill Authority-Bridgeton	29189	0312	562212	244.28
Flex-O-Lite Inc-Fenton	29189	0315	327215	-
Pro-Tect Mfg Inc-Ferguson Ave	29189	0317	32614	
St Marys Health Center-Richmond Heights	29189	0318	62211	6.74
Camie-Campbell Inc-Watson Industrial Park	29189	0327	325520	
Belt Service Corp-Earth City	29189	1012	326220	0.47
Kv Pharmaceutical Company-Brentwood	29189	1015	325412	-
Depaul Health Center-Bridgeton	29189	1029	62211	6.05
Kv Pharmaceutical Company-Schuetz Rd	29189	1047	325412	1.22
Veterans Admin Medical Center-Jefferson Barracks Drive	29189	1052	62211	-
Reichhold Chemicals Inc-Valley Park	29189	1097	325211	4.40
St Luke'S Hospital-Woods Mill Road	29189	1101	62211	5.24
St Joseph Hospital-Kirkwood	29189	1156	62211	2.99
Pan-Glo St Louis-Trenton Avenue	29189	1192	811310	
Whitmire Microgen Research Laboratory-Kirkwood	29189	1204	32532	
Metropolitan St Louis Sewer District-Mo River Wasterwater Treatment Plant	29189	1205	22132	7.10
Metropolitan St Louis Sewer District-Coldwater Creek Sewage Treatment Plant	29189	1210	22132	50.69
Simpson Construction Materials Llc-Valley Park	29189	1226	324121	20.28
Fred Weber Inc-South Asphalt	29189	1248	324121	24.49
Fred Weber Inc-North Asphalt H & B	29189	1249	324121	37.15
Fred Weber Inc-North Asphalt B & G	29189	1250	324121	37.42
Gkn Aerospace Services Inc-Berkeley	29189	1489	336413	11.36
F & S Real Eastate Inc-St Louis	29189	1520	323112	
KV PHARMACEUTICAL-BRIDGETON	29189	1538	325412	-
Conagra Foods-Marshall Plant	29195	0004	311412	4.08
Marshall Municipal Utilities	29195	0010	221112	45.49
MID-MISSOURI ENERGY INC-MALTA BEND	29195	0046	325193	64.50
Tetra Pak Materials-Sikeston	29201	0003	32213	-
Sikeston Power Station-Sikeston Power Station	29201	0017	221112	287.95
TEPPCO-Cape Girardeau Terminal	29201	0018	48691	
Havco Wood Products Inc-Havco Wood Products Inc	29201	0021	321113	57.98
Crowder Gin Company Inc-Sikeston	29201	0073	115111	0.03
Texas Eastern Transmission Corporation-Oran Facility	29201	0099	48621	29.32

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Manac Trailers Usa Inc-Oran	29201	0102	333294	0.01
CONSTRUCTION TRAILER SPECIALISTS INC-SIKESTON	29201	0110	336212	
CONSOLIDATED GRAIN AND BARGE CO-CONSOLIDATED GRAIN AND BARGE CO	29201	8001	424510	0.23
Missouri Hardwood Flooring Co-Missouri Hardwood Flooring Co	29203	0005	321113	19.55
Cerro Copper Tube Company-Cerro Copper Tube Company	29205	0010	331421	82.30
Shelbina Power Plant	29205	0011	221112	0.01
Ames True Temper Inc-Bernie North Plant	29207	0007	321999	6.92
J P Ross Cotton Co Inc-J P Ross Cotton Co Inc	29207	0008	115111	0.05
Nestle Purina Petcare Company-Bloomfield	29207	0014	212324	43.19
Stoddard County Cotton Co-Bernie	29207	0018	115111	0.23
W W Wood Products-Dudley	29207	0019	321113	0.64
Lemons Sanitary Landfill-Lemons Sanitary Landfill	29207	0062	562212	67.28
Essex Power Plant	29207	0064	221112	0.01
Table Rock Asphalt Constr Co Inc-Quarry #3 & Concrete Plant	29209	0007	212312	
Horner Charcoal Co Inc-Horner Charcoal Co Inc	29213	0002	325191	0.86
Table Rock Asphalt Constr Co Inc-Hwy 248 Quarry	29213	0003	212312	1.03
Royal Oak Enterprises-Royal Oak Enterprises	29213	0007	325191	26.06
College Of The Ozarks-Branson	29213	0048	61131	1.85
Dairy Farmers Of America Inc-Cabool	29215	0026	311514	7.69
Woodpro Cabinetry Inc-Cabool	29215	0060	33711	9.92
3M Company-Nevada - Commercial Graphics	29217	0004	326121	20.58
Aquila Inc-Nevada Gas Turbine	29217	0034	221112	0.01
PRAIRIE PRIDE INC-EVE	29217	0043	311222	10.61
Holland Usa-Warrenton Facility	29219	0013	332117	0.00
Warrenton Copper Llc-Warrenton	29219	0028	331314	6.59
Greif Inc-Wright City	29219	0036	322214	0.09
Cascades Plastics Inc-Warrenton	29219	0038	32614	
Red Wing Shoe Company Inc-Potosi	29221	0008	316214	
Buckman Laboratories Inc-Cadet	29221	0018	311942	2.45
Purcell Tire-Purcell Tire	29221	0022	443112	2.10
IESI CORPORATION-TIMBER RIDGE LANDFILL	29221	0031	562212	
Steel Processors-Steel Processors	29225	0026	336212	0.31
Hutchens Industries-Mansfield Steel Div	29229	0001	336212	0.29
Black Oak Recycling & Disposal Facility-Div Waste Corporation Of America	29229	0022	562212	39.35
Anheuser-Busch Inc-St Louis	29510	0003	312120	145.98
Mallinckrodt Inc -Mallinckrodt Inc	29510	0017	32511	77.49
Precoat Metals-Precoat Metals	29510	0027	332812	5.10
ADM Gromark River Systems-St Louis	29510	0031	311211	0.00
Trigen-St Louis Energy Corp-Ashley Street Station	29510	0038	221112	46.27
Washington Univ Medical School-Boiler Plant	29510	0040	62211	28.23
Fred Weber Inc-Asphalt Plant	29510	0047	324121	9.56
Metropolitan St Louis Sewer District-Bissel Plant	29510	0053	92411	552.29

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Procter & Gamble-Procter & Gamble	29510	0057	325611	9.89
Dial Corp-Dial Corp	29510	0063	325611	8.39
Elementis Specialties Inc-Elementis Specialties Inc	29510	0066	325131	6.78
Astaris Llc-Carondelet Plant	29510	0070	211112	27.07
P D George Co (The)-P D George Co (The)	29510	0096	32551	3.73
U S Paint Div Of Grow Group-U S Paint Div Of Grow Group	29510	0097	32551	
Alumax Foils Inc-Alcoa Foil Products/Alumax Foils Inc	29510	0118	322225	14.02
ADM/TPC Milling Co-Pillsbury Company	29510	0159	311211	-
Poly One Corporation-St Louis	29510	0161	32551	
Marquette Tool & Die-Marquette Tool & Die	29510	0162	314999	
St Louis Metallizing-St Louis	29510	0175	332812	0.08
Italgrani Elevator-Italgrani Elevator	29510	0179	42451	3.22
St Alexius Hospital-St Louis	29510	0200	62211	0.33
Bjc Health System-Pavillion	29510	0204	62211	1.51
Sensient Colors Inc-Baldwin Plant	29510	0269	31192	2.41
Hermann Oak Leather Co-Hermann Oak Leather Co	29510	0391	31611	-
Lange-Stegmann Co-Lange-Stegmann Co	29510	0468	42491	0.00
Sigma - Aldrich Co-Sigma - Aldrich Co	29510	0697	325199	3.14
Chemisphere Corporation-Chemisphere	29510	0808	32511	
PQ Corporation (The)-St Louis	29510	0809	211112	9.65
Interstate Brands Corp-Interstate Brands Corp	29510	0938	311812	1.27
Goodwin Printing Co -St Louis	29510	1055	323110	
Mid-West Industrial Chemical-Mid-West Industrial Chemical	29510	1077	32552	-
Brenntag Mid-South Inc-Brenntag Mid-South Inc	29510	1093	42392	0.00
U S Ringbinder Corp-Loose Leaf Metals	29510	1123	323116	
St Louis Post Dispatch-St Louis Post Dispatch	29510	1280	51111	0.44
National Geospatial-Intelligence Agency-National Geospatial-Intelligence Agency	29510	1370	92811	1.38
Sigma - Aldrich Co-Sigma Chemical Company	29510	1396	325414	4.92
Southern Metal Processing-Southern Metal Processing	29510	1407	333414	2.17
Ashland Distribution Company-St Louis Plant	29510	1423	311942	
Allied Health Care Products-Allied Health Care Products	29510	1460	332919	-
Energy Center (The)-St Louis Univ Health Sciences Center	29510	1505	621111	9.43
Permacel St Louis Inc-Permacel St Louis Inc	29510	1519	326299	2.30
Connector Castings-Connector Castings	29510	1556	331314	0.00
J S Alberici Construction-J S Alberici Construction	29510	1642	236220	-
Superior Solvent & Chemical-St Louis	29510	2300	49311	
Laclede Tower Associates Llc-Laclede Gas Building	29510	2378	22121	320.75
New World Pasta- Marceau Facility-New World Pasta	29510	2433	311823	4.59
Southwestern Bell Telephone Company-Southwestern Bell Telephone Company	29510	2545	517110	6.68
St Louis University-Facilities Svcs	29510	2711	323110	9.70
WASHINGTON UNIVERSITY-HILLTOP CAMPUS	29510	2833	611310	1.06

Facility Name	State County FIPS Code	Facility ID	NAICS	CO Emissions (tons/year)
Statewide Total				92,239.10

Appendix A-2

List of On-Road Mobile Source Emissions by SCC for St. Louis County and St. Louis City (tons/year)

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Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis County	220100100X	Off-Network	Light Duty Gasoline Vehicles (LDGV)	Exhaust	23,231.78
St. Louis County	220100111X	Rural Interstate	Light Duty Gasoline Vehicles (LDGV)	Exhaust	42.35
St. Louis County	220100113X	Rural Principal Arterial	Light Duty Gasoline Vehicles (LDGV)	Exhaust	92.46
St. Louis County	220100115X	Rural Minor Arterial	Light Duty Gasoline Vehicles (LDGV)	Exhaust	43.77
St. Louis County	220100117X	Rural Major Collector	Light Duty Gasoline Vehicles (LDGV)	Exhaust	84.79
St. Louis County	220100119X	Rural Minor Collector	Light Duty Gasoline Vehicles (LDGV)	Exhaust	-
St. Louis County	220100121X	Rural Local	Light Duty Gasoline Vehicles (LDGV)	Exhaust	56.87
St. Louis County	220100123X	Urban Interstate	Light Duty Gasoline Vehicles (LDGV)	Exhaust	8,912.00
St. Louis County	220100125X	Urban Freeway/Expressway	Light Duty Gasoline Vehicles (LDGV)	Exhaust	1,981.59
St. Louis County	220100127X	Urban Principal Arterial	Light Duty Gasoline Vehicles (LDGV)	Exhaust	3,686.99
St. Louis County	220100129X	Urban Minor Arterial	Light Duty Gasoline Vehicles (LDGV)	Exhaust	2,437.24
St. Louis County	220100131X	Urban Collector	Light Duty Gasoline Vehicles (LDGV)	Exhaust	1,299.25
St. Louis County	220100133X	Urban Local	Light Duty Gasoline Vehicles (LDGV)	Exhaust	4,799.43
St. Louis County	220102000X	Off-Network	Light Duty Gasoline Trucks 1 & 2	Exhaust	18,311.11
St. Louis County	220102011X	Rural Interstate	Light Duty Gasoline Trucks 1 & 2	Exhaust	49.09
St. Louis County	220102013X	Rural Principal Arterial	Light Duty Gasoline Trucks 1 & 2	Exhaust	111.16
St. Louis County	220102015X	Rural Minor Arterial	Light Duty Gasoline Trucks 1 & 2	Exhaust	52.62
St. Louis County	220102017X	Rural Major Collector	Light Duty Gasoline Trucks 1 & 2	Exhaust	101.94
St. Louis County	220102019X	Rural Minor Collector	Light Duty Gasoline Trucks 1 & 2	Exhaust	-
St. Louis County	220102021X	Rural Local	Light Duty Gasoline Trucks 1 & 2	Exhaust	68.37
St. Louis County	220102023X	Urban Interstate	Light Duty Gasoline Trucks 1 & 2	Exhaust	11,379.00

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis County	220102025X	Urban Freeway/Expressway	Light Duty Gasoline Trucks 1 & 2	Exhaust	2,530.13
St. Louis County	220102027X	Urban Principal Arterial	Light Duty Gasoline Trucks 1 & 2	Exhaust	4,433.25
St. Louis County	220102029X	Urban Minor Arterial	Light Duty Gasoline Trucks 1 & 2	Exhaust	2,930.54
St. Louis County	220102031X	Urban Collector	Light Duty Gasoline Trucks 1 & 2	Exhaust	1,562.22
St. Louis County	220102033X	Urban Local	Light Duty Gasoline Trucks 1 & 2	Exhaust	5,770.85
St. Louis County	220104000X	Off-Network	Light Duty Gasoline Trucks 3 and 4	Exhaust	9,432.99
St. Louis County	220104011X	Rural Interstate	Light Duty Gasoline Trucks 3 and 4	Exhaust	25.29
St. Louis County	220104013X	Rural Principal Arterial	Light Duty Gasoline Trucks 3 and 4	Exhaust	57.27
St. Louis County	220104015X	Rural Minor Arterial	Light Duty Gasoline Trucks 3 and 4	Exhaust	27.11
St. Louis County	220104017X	Rural Major Collector	Light Duty Gasoline Trucks 3 and 4	Exhaust	52.51
St. Louis County	220104019X	Rural Minor Collector	Light Duty Gasoline Trucks 3 and 4	Exhaust	-
St. Louis County	220104021X	Rural Local	Light Duty Gasoline Trucks 3 and 4	Exhaust	35.22
St. Louis County	220104023X	Urban Interstate	Light Duty Gasoline Trucks 3 and 4	Exhaust	5,861.91
St. Louis County	220104025X	Urban Freeway/Expressway	Light Duty Gasoline Trucks 3 and 4	Exhaust	1,303.40
St. Louis County	220104027X	Urban Principal Arterial	Light Duty Gasoline Trucks 3 and 4	Exhaust	2,283.79
St. Louis County	220104029X	Urban Minor Arterial	Light Duty Gasoline Trucks 3 and 4	Exhaust	1,509.67
St. Louis County	220104031X	Urban Collector	Light Duty Gasoline Trucks 3 and 4	Exhaust	804.78
St. Louis County	220104033X	Urban Local	Light Duty Gasoline Trucks 3 and 4	Exhaust	2,972.86
St. Louis County	220107000X	Off-Network	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	2,637.96
St. Louis County	220107011X	Rural Interstate	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	7.63
St. Louis County	220107013X	Rural Principal Arterial	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	18.99
St. Louis County	220107015X	Rural Minor Arterial	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	8.99

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis County	220107017X	Rural Major Collector	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	17.41
St. Louis County	220107019X	Rural Minor Collector	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	-
St. Louis County	220107021X	Rural Local	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	11.68
St. Louis County	220107023X	Urban Interstate	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	1,918.39
St. Louis County	220107025X	Urban Freeway/Expressway	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	426.56
St. Louis County	220107027X	Urban Principal Arterial	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	777.97
St. Louis County	220107029X	Urban Minor Arterial	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	514.26
St. Louis County	220107031X	Urban Collector	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	274.14
St. Louis County	220107033X	Urban Local	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	1,012.70
St. Louis County	220108000X	Off-Network	Motorcycles (MC)	Exhaust	83.09
St. Louis County	220108011X	Rural Interstate	Motorcycles (MC)	Exhaust	2.21
St. Louis County	220108013X	Rural Principal Arterial	Motorcycles (MC)	Exhaust	7.69
St. Louis County	220108015X	Rural Minor Arterial	Motorcycles (MC)	Exhaust	3.64
St. Louis County	220108017X	Rural Major Collector	Motorcycles (MC)	Exhaust	7.05
St. Louis County	220108019X	Rural Minor Collector	Motorcycles (MC)	Exhaust	-
St. Louis County	220108021X	Rural Local	Motorcycles (MC)	Exhaust	4.73
St. Louis County	220108023X	Urban Interstate	Motorcycles (MC)	Exhaust	771.73
St. Louis County	220108025X	Urban Freeway/Expressway	Motorcycles (MC)	Exhaust	171.60
St. Louis County	220108027X	Urban Principal Arterial	Motorcycles (MC)	Exhaust	298.99
St. Louis County	220108029X	Urban Minor Arterial	Motorcycles (MC)	Exhaust	197.64
St. Louis County	220108031X	Urban Collector	Motorcycles (MC)	Exhaust	105.36
St. Louis County	220108033X	Urban Local	Motorcycles (MC)	Exhaust	389.20

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis County	223000100X	Off-Network	Light Duty Diesel Vehicles (LDDV)	Exhaust	3.01
St. Louis County	223000111X	Rural Interstate	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.00
St. Louis County	223000113X	Rural Principal Arterial	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.02
St. Louis County	223000115X	Rural Minor Arterial	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.01
St. Louis County	223000117X	Rural Major Collector	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.02
St. Louis County	223000119X	Rural Minor Collector	Light Duty Diesel Vehicles (LDDV)	Exhaust	-
St. Louis County	223000121X	Rural Local	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.01
St. Louis County	223000123X	Urban Interstate	Light Duty Diesel Vehicles (LDDV)	Exhaust	1.34
St. Louis County	223000125X	Urban Freeway/Expressway	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.30
St. Louis County	223000127X	Urban Principal Arterial	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.80
St. Louis County	223000129X	Urban Minor Arterial	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.53
St. Louis County	223000131X	Urban Collector	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.28
St. Louis County	223000133X	Urban Local	Light Duty Diesel Vehicles (LDDV)	Exhaust	1.04
St. Louis County	223006000X	Off-Network	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	13.15
St. Louis County	223006011X	Rural Interstate	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	0.18
St. Louis County	223006013X	Rural Principal Arterial	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	0.86
St. Louis County	223006015X	Rural Minor Arterial	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	0.41
St. Louis County	223006017X	Rural Major Collector	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	0.79
St. Louis County	223006019X	Rural Minor Collector	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	-
St. Louis County	223006021X	Rural Local	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	0.53
St. Louis County	223006023X	Urban Interstate	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	77.82
St. Louis County	223006025X	Urban Freeway/Expressway	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	17.30

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis County	223006027X	Urban Principal Arterial	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	44.94
St. Louis County	223006029X	Urban Minor Arterial	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	29.71
St. Louis County	223006031X	Urban Collector	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	15.84
St. Louis County	223006033X	Urban Local	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	58.50
St. Louis County	223007100X	Off-Network	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	5.71
St. Louis County	223007111X	Rural Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	0.08
St. Louis County	223007113X	Rural Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	0.38
St. Louis County	223007115X	Rural Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	0.18
St. Louis County	223007117X	Rural Major Collector	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	0.35
St. Louis County	223007119X	Rural Minor Collector	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	-
St. Louis County	223007121X	Rural Local	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	0.23
St. Louis County	223007123X	Urban Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	34.32
St. Louis County	223007125X	Urban Freeway/Expressway	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	7.63
St. Louis County	223007127X	Urban Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	19.82
St. Louis County	223007129X	Urban Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	13.10
St. Louis County	223007131X	Urban Collector	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	6.98
St. Louis County	223007133X	Urban Local	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	25.80
St. Louis County	223007200X	Off-Network	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	30.70
St. Louis County	223007211X	Rural Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	0.43
St. Louis County	223007213X	Rural Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	2.07
St. Louis County	223007215X	Rural Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	0.98
St. Louis County	223007217X	Rural Major Collector	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	1.90

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis County	223007219X	Rural Minor Collector	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	-
St. Louis County	223007221X	Rural Local	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	1.27
St. Louis County	223007223X	Urban Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	186.81
St. Louis County	223007225X	Urban Freeway/Expressway	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	41.54
St. Louis County	223007227X	Urban Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	107.92
St. Louis County	223007229X	Urban Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	71.34
St. Louis County	223007231X	Urban Collector	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	38.03
St. Louis County	223007233X	Urban Local	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	140.48
St. Louis County	223007300X	Off-Network	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	46.26
St. Louis County	223007311X	Rural Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	0.59
St. Louis County	223007313X	Rural Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	2.60
St. Louis County	223007315X	Rural Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	1.23
St. Louis County	223007317X	Rural Major Collector	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	2.38
St. Louis County	223007319X	Rural Minor Collector	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	-
St. Louis County	223007321X	Rural Local	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	1.60
St. Louis County	223007323X	Urban Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	217.78
St. Louis County	223007325X	Urban Freeway/Expressway	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	48.42
St. Louis County	223007327X	Urban Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	116.12
St. Louis County	223007329X	Urban Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	76.76
St. Louis County	223007331X	Urban Collector	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	40.92
St. Louis County	223007333X	Urban Local	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	151.15
St. Louis County	223007400X	Off-Network	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	472.81

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis County	223007411X	Rural Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	2.31
St. Louis County	223007413X	Rural Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	9.68
St. Louis County	223007415X	Rural Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	4.58
St. Louis County	223007417X	Rural Major Collector	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	8.87
St. Louis County	223007419X	Rural Minor Collector	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	-
St. Louis County	223007421X	Rural Local	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	5.95
St. Louis County	223007423X	Urban Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	826.54
St. Louis County	223007425X	Urban Freeway/Expressway	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	183.78
St. Louis County	223007427X	Urban Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	431.19
St. Louis County	223007429X	Urban Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	285.03
St. Louis County	223007431X	Urban Collector	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	151.94
St. Louis County	223007433X	Urban Local	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	561.28
St. Louis County	223007500X	Off-Network	Heavy Duty Diesel Buses (School and Transit)	Exhaust	32.97
St. Louis County	223007511X	Rural Interstate	Heavy Duty Diesel Buses (School and Transit)	Exhaust	0.19
St. Louis County	223007513X	Rural Principal Arterial	Heavy Duty Diesel Buses (School and Transit)	Exhaust	0.63
St. Louis County	223007515X	Rural Minor Arterial	Heavy Duty Diesel Buses (School and Transit)	Exhaust	0.30
St. Louis County	223007517X	Rural Major Collector	Heavy Duty Diesel Buses (School and Transit)	Exhaust	0.58
St. Louis County	223007519X	Rural Minor Collector	Heavy Duty Diesel Buses (School and Transit)	Exhaust	-
St. Louis County	223007521X	Rural Local	Heavy Duty Diesel Buses (School and Transit)	Exhaust	0.39
St. Louis County	223007523X	Urban Interstate	Heavy Duty Diesel Buses (School and Transit)	Exhaust	69.03
St. Louis County	223007525X	Urban Freeway/Expressway	Heavy Duty Diesel Buses (School and Transit)	Exhaust	15.35
St. Louis County	223007527X	Urban Principal Arterial	Heavy Duty Diesel Buses (School and Transit)	Exhaust	22.90

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis County	223007529X	Urban Minor Arterial	Heavy Duty Diesel Buses (School and Transit)	Exhaust	15.14
St. Louis County	223007531X	Urban Collector	Heavy Duty Diesel Buses (School and Transit)	Exhaust	8.07
St. Louis County	223007533X	Urban Local	Heavy Duty Diesel Buses (School and Transit)	Exhaust	29.81
St. Louis County Total					**132,855.83**
St. Louis City	220100100X	Off-Network	Light Duty Gasoline Vehicles (LDGV)	Exhaust	5,479.03
St. Louis City	220100111X	Rural Interstate	Light Duty Gasoline Vehicles (LDGV)	Exhaust	-
St. Louis City	220100113X	Rural Principal Arterial	Light Duty Gasoline Vehicles (LDGV)	Exhaust	-
St. Louis City	220100115X	Rural Minor Arterial	Light Duty Gasoline Vehicles (LDGV)	Exhaust	-
St. Louis City	220100117X	Rural Major Collector	Light Duty Gasoline Vehicles (LDGV)	Exhaust	-
St. Louis City	220100119X	Rural Minor Collector	Light Duty Gasoline Vehicles (LDGV)	Exhaust	-
St. Louis City	220100121X	Rural Local	Light Duty Gasoline Vehicles (LDGV)	Exhaust	-
St. Louis City	220100123X	Urban Interstate	Light Duty Gasoline Vehicles (LDGV)	Exhaust	2,813.60
St. Louis City	220100125X	Urban Freeway/Expressway	Light Duty Gasoline Vehicles (LDGV)	Exhaust	-
St. Louis City	220100127X	Urban Principal Arterial	Light Duty Gasoline Vehicles (LDGV)	Exhaust	1,206.30
St. Louis City	220100129X	Urban Minor Arterial	Light Duty Gasoline Vehicles (LDGV)	Exhaust	797.84
St. Louis City	220100131X	Urban Collector	Light Duty Gasoline Vehicles (LDGV)	Exhaust	425.96
St. Louis City	220100133X	Urban Local	Light Duty Gasoline Vehicles (LDGV)	Exhaust	1,570.28
St. Louis City	220102000X	Off-Network	Light Duty Gasoline Trucks 1 & 2	Exhaust	3,609.69
St. Louis City	220102011X	Rural Interstate	Light Duty Gasoline Trucks 1 & 2	Exhaust	-
St. Louis City	220102013X	Rural Principal Arterial	Light Duty Gasoline Trucks 1 & 2	Exhaust	-
St. Louis City	220102015X	Rural Minor Arterial	Light Duty Gasoline Trucks 1 & 2	Exhaust	-
St. Louis City	220102017X	Rural Major Collector	Light Duty Gasoline Trucks 1 & 2	Exhaust	-

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis City	220102019X	Rural Minor Collector	Light Duty Gasoline Trucks 1 & 2	Exhaust	-
St. Louis City	220102021X	Rural Local	Light Duty Gasoline Trucks 1 & 2	Exhaust	-
St. Louis City	220102023X	Urban Interstate	Light Duty Gasoline Trucks 1 & 2	Exhaust	3,617.21
St. Louis City	220102025X	Urban Freeway/Expressway	Light Duty Gasoline Trucks 1 & 2	Exhaust	-
St. Louis City	220102027X	Urban Principal Arterial	Light Duty Gasoline Trucks 1 & 2	Exhaust	1,448.26
St. Louis City	220102029X	Urban Minor Arterial	Light Duty Gasoline Trucks 1 & 2	Exhaust	957.87
St. Louis City	220102031X	Urban Collector	Light Duty Gasoline Trucks 1 & 2	Exhaust	511.40
St. Louis City	220102033X	Urban Local	Light Duty Gasoline Trucks 1 & 2	Exhaust	1,885.26
St. Louis City	220104000X	Off-Network	Light Duty Gasoline Trucks 3 and 4	Exhaust	1,859.54
St. Louis City	220104011X	Rural Interstate	Light Duty Gasoline Trucks 3 and 4	Exhaust	-
St. Louis City	220104013X	Rural Principal Arterial	Light Duty Gasoline Trucks 3 and 4	Exhaust	-
St. Louis City	220104015X	Rural Minor Arterial	Light Duty Gasoline Trucks 3 and 4	Exhaust	-
St. Louis City	220104017X	Rural Major Collector	Light Duty Gasoline Trucks 3 and 4	Exhaust	-
St. Louis City	220104019X	Rural Minor Collector	Light Duty Gasoline Trucks 3 and 4	Exhaust	-
St. Louis City	220104021X	Rural Local	Light Duty Gasoline Trucks 3 and 4	Exhaust	-
St. Louis City	220104023X	Urban Interstate	Light Duty Gasoline Trucks 3 and 4	Exhaust	1,863.41
St. Louis City	220104025X	Urban Freeway/Expressway	Light Duty Gasoline Trucks 3 and 4	Exhaust	-
St. Louis City	220104027X	Urban Principal Arterial	Light Duty Gasoline Trucks 3 and 4	Exhaust	746.08
St. Louis City	220104029X	Urban Minor Arterial	Light Duty Gasoline Trucks 3 and 4	Exhaust	493.45
St. Louis City	220104031X	Urban Collector	Light Duty Gasoline Trucks 3 and 4	Exhaust	263.45
St. Louis City	220104033X	Urban Local	Light Duty Gasoline Trucks 3 and 4	Exhaust	971.19
St. Louis City	220107000X	Off-Network	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	582.21

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis City	220107011X	Rural Interstate	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	-
St. Louis City	220107013X	Rural Principal Arterial	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	-
St. Louis City	220107015X	Rural Minor Arterial	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	-
St. Louis City	220107017X	Rural Major Collector	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	-
St. Louis City	220107019X	Rural Minor Collector	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	-
St. Louis City	220107021X	Rural Local	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	-
St. Louis City	220107023X	Urban Interstate	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	606.29
St. Louis City	220107025X	Urban Freeway/Expressway	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	-
St. Louis City	220107027X	Urban Principal Arterial	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	254.42
St. Louis City	220107029X	Urban Minor Arterial	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	168.27
St. Louis City	220107031X	Urban Collector	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	89.84
St. Louis City	220107033X	Urban Local	Heavy Duty Gasoline Vehicles 2B thru 8B and Gasoline Buses	Exhaust	331.19
St. Louis City	220108000X	Off-Network	Motorcycles (MC)	Exhaust	13.15
St. Louis City	220108011X	Rural Interstate	Motorcycles (MC)	Exhaust	-
St. Louis City	220108013X	Rural Principal Arterial	Motorcycles (MC)	Exhaust	-
St. Louis City	220108015X	Rural Minor Arterial	Motorcycles (MC)	Exhaust	-
St. Louis City	220108017X	Rural Major Collector	Motorcycles (MC)	Exhaust	-
St. Louis City	220108019X	Rural Minor Collector	Motorcycles (MC)	Exhaust	-
St. Louis City	220108021X	Rural Local	Motorcycles (MC)	Exhaust	-
St. Louis City	220108023X	Urban Interstate	Motorcycles (MC)	Exhaust	242.33
St. Louis City	220108025X	Urban Freeway/Expressway	Motorcycles (MC)	Exhaust	-
St. Louis City	220108027X	Urban Principal Arterial	Motorcycles (MC)	Exhaust	97.39

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis City	220108029X	Urban Minor Arterial	Motorcycles (MC)	Exhaust	64.41
St. Louis City	220108031X	Urban Collector	Motorcycles (MC)	Exhaust	34.39
St. Louis City	220108033X	Urban Local	Motorcycles (MC)	Exhaust	126.78
St. Louis City	223000100X	Off-Network	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.71
St. Louis City	223000111X	Rural Interstate	Light Duty Diesel Vehicles (LDDV)	Exhaust	-
St. Louis City	223000113X	Rural Principal Arterial	Light Duty Diesel Vehicles (LDDV)	Exhaust	-
St. Louis City	223000115X	Rural Minor Arterial	Light Duty Diesel Vehicles (LDDV)	Exhaust	-
St. Louis City	223000117X	Rural Major Collector	Light Duty Diesel Vehicles (LDDV)	Exhaust	-
St. Louis City	223000119X	Rural Minor Collector	Light Duty Diesel Vehicles (LDDV)	Exhaust	-
St. Louis City	223000121X	Rural Local	Light Duty Diesel Vehicles (LDDV)	Exhaust	-
St. Louis City	223000123X	Urban Interstate	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.42
St. Louis City	223000125X	Urban Freeway/Expressway	Light Duty Diesel Vehicles (LDDV)	Exhaust	-
St. Louis City	223000127X	Urban Principal Arterial	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.26
St. Louis City	223000129X	Urban Minor Arterial	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.17
St. Louis City	223000131X	Urban Collector	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.09
St. Louis City	223000133X	Urban Local	Light Duty Diesel Vehicles (LDDV)	Exhaust	0.34
St. Louis City	223006000X	Off-Network	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	2.65
St. Louis City	223006011X	Rural Interstate	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	-
St. Louis City	223006013X	Rural Principal Arterial	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	-
St. Louis City	223006015X	Rural Minor Arterial	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	-
St. Louis City	223006017X	Rural Major Collector	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	-
St. Louis City	223006019X	Rural Minor Collector	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	-

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis City	223006021X	Rural Local	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	-
St. Louis City	223006023X	Urban Interstate	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	25.39
St. Louis City	223006025X	Urban Freeway/Expressway	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	-
St. Louis City	223006027X	Urban Principal Arterial	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	15.06
St. Louis City	223006029X	Urban Minor Arterial	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	9.96
St. Louis City	223006031X	Urban Collector	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	5.32
St. Louis City	223006033X	Urban Local	Light Duty Diesel Trucks 1 thru 4 (LDDT)	Exhaust	19.61
St. Louis City	223007100X	Off-Network	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	1.15
St. Louis City	223007111X	Rural Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	-
St. Louis City	223007113X	Rural Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	-
St. Louis City	223007115X	Rural Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	-
St. Louis City	223007117X	Rural Major Collector	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	-
St. Louis City	223007119X	Rural Minor Collector	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	-
St. Louis City	223007121X	Rural Local	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	-
St. Louis City	223007123X	Urban Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	11.19
St. Louis City	223007125X	Urban Freeway/Expressway	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	-
St. Louis City	223007127X	Urban Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	6.63
St. Louis City	223007129X	Urban Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	4.39
St. Louis City	223007131X	Urban Collector	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	2.34
St. Louis City	223007133X	Urban Local	Heavy Duty Diesel Vehicles (HDDV) Class 2B	Exhaust	8.64
St. Louis City	223007200X	Off-Network	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	6.19
St. Louis City	223007211X	Rural Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	-

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis City	223007213X	Rural Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	-
St. Louis City	223007215X	Rural Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	-
St. Louis City	223007217X	Rural Major Collector	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	-
St. Louis City	223007219X	Rural Minor Collector	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	-
St. Louis City	223007221X	Rural Local	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	-
St. Louis City	223007223X	Urban Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	61.09
St. Louis City	223007225X	Urban Freeway/Expressway	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	-
St. Louis City	223007227X	Urban Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	36.26
St. Louis City	223007229X	Urban Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	23.98
St. Louis City	223007231X	Urban Collector	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	12.80
St. Louis City	223007233X	Urban Local	Heavy Duty Diesel Vehicles (HDDV) Class 3, 4, and 5	Exhaust	47.20
St. Louis City	223007300X	Off-Network	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	14.50
St. Louis City	223007311X	Rural Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	-
St. Louis City	223007313X	Rural Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	-
St. Louis City	223007315X	Rural Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	-
St. Louis City	223007317X	Rural Major Collector	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	-
St. Louis City	223007319X	Rural Minor Collector	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	-
St. Louis City	223007321X	Rural Local	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	-
St. Louis City	223007323X	Urban Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	69.65
St. Louis City	223007325X	Urban Freeway/Expressway	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	-
St. Louis City	223007327X	Urban Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	38.13
St. Louis City	223007329X	Urban Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	25.22

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis City	223007331X	Urban Collector	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	13.47
St. Louis City	223007333X	Urban Local	Heavy Duty Diesel Vehicles (HDDV) Class 6 and 7	Exhaust	49.64
St. Louis City	223007400X	Off-Network	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	136.61
St. Louis City	223007411X	Rural Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	-
St. Louis City	223007413X	Rural Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	-
St. Louis City	223007415X	Rural Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	-
St. Louis City	223007417X	Rural Major Collector	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	-
St. Louis City	223007419X	Rural Minor Collector	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	-
St. Louis City	223007421X	Rural Local	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	-
St. Louis City	223007423X	Urban Interstate	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	263.29
St. Louis City	223007425X	Urban Freeway/Expressway	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	-
St. Louis City	223007427X	Urban Principal Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	139.88
St. Louis City	223007429X	Urban Minor Arterial	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	92.51
St. Louis City	223007431X	Urban Collector	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	49.39
St. Louis City	223007433X	Urban Local	Heavy Duty Diesel Vehicles (HDDV) Class 8A and 8B	Exhaust	182.08
St. Louis City	223007500X	Off-Network	Heavy Duty Diesel Buses (School and Transit)	Exhaust	9.88
St. Louis City	223007511X	Rural Interstate	Heavy Duty Diesel Buses (School and Transit)	Exhaust	-
St. Louis City	223007513X	Rural Principal Arterial	Heavy Duty Diesel Buses (School and Transit)	Exhaust	-
St. Louis City	223007515X	Rural Minor Arterial	Heavy Duty Diesel Buses (School and Transit)	Exhaust	-
St. Louis City	223007517X	Rural Major Collector	Heavy Duty Diesel Buses (School and Transit)	Exhaust	-
St. Louis City	223007519X	Rural Minor Collector	Heavy Duty Diesel Buses (School and Transit)	Exhaust	-
St. Louis City	223007521X	Rural Local	Heavy Duty Diesel Buses (School and Transit)	Exhaust	-

Area	SCC	SCC Road Type	SCC Vehicle Type	SCC Process Type	CO Emissions (tons/year)
St. Louis City	223007523X	Urban Interstate	Heavy Duty Diesel Buses (School and Transit)	Exhaust	28.04
St. Louis City	223007525X	Urban Freeway/Expressway	Heavy Duty Diesel Buses (School and Transit)	Exhaust	-
St. Louis City	223007527X	Urban Principal Arterial	Heavy Duty Diesel Buses (School and Transit)	Exhaust	9.69
St. Louis City	223007529X	Urban Minor Arterial	Heavy Duty Diesel Buses (School and Transit)	Exhaust	6.41
St. Louis City	223007531X	Urban Collector	Heavy Duty Diesel Buses (School and Transit)	Exhaust	3.42
St. Louis City	223007533X	Urban Local	Heavy Duty Diesel Buses (School and Transit)	Exhaust	12.61
St. Louis City Total					**34,576.81**
Combined Total For St. Louis County and St. Louis City					**167,432.64**

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Documentation for Aircraft Component of the National Emissions Inventory Methodology

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1.0 INTRODUCTION

1.1 What is the National Emission Inventory?

The National Emission Inventory (NEI) is a comprehensive inventory covering all anthropogenic sources of criteria pollutants and hazardous air pollutants (HAPs) for all areas of the United States. The NEI was created by the U.S. Environmental Protection Agency's Emission Inventory and Analysis Group (EIAG) in Research Triangle Park, North Carolina. The NEI will be used to support air quality modeling and other activities. To this end, the EPA established a goal to compile comprehensive emissions data in the NEI for criteria and HAPs for mobile, point, and nonpoint sources. This report presents an overview of how emission estimates for the aircraft component of the NEI were compiled.

1.2 Why Did the EPA Create the NEI?

The Clean Air Act (CAA), as amended in 1990, includes mandates for the EPA related to criteria and hazardous air pollutants. The CAA defines criteria pollutants as being one of the following air pollutants:

- Carbon monoxide (CO);
- Sulfur oxides (SO_x);
- Nitrogen oxides (NO_x);
- Ozone; and
- Particulate matter (PM).

Hazardous air pollutants are also delineated in the CAA, see *http://www.epa.gov/ttn/atw/188polls.html* for a complete list of regulated pollutants and their chemical abstract service [CAS] numbers.

The CAA requires the EPA to identify emission sources of these pollutants, quantify emissions, develop regulations for the identified source categories, and assess the public health and environmental impacts after the regulations are put into effect. The NEI is a tool that EPA can use to meet the CAA mandates. In this report, criteria and HAP emission estimates are discussed for aircraft sources.

1.3 How is the EPA Going to Use This Version of the NEI?

It is anticipated that the emission inventory developed from this effort will have multiple end uses. The data have been formatted according to protocols established for the EPA's NEI submittals. The common data structure on which the NEI platform is based will allow the NEI emission data to be transferred to multiple end-users for a variety of purposes.

The criteria and HAP emission estimates developed for the NEI will be used to evaluate air pollution trends, air quality modeling analysis, and impacts of potential regulations.

1.4 Report Organization

Following this introduction, Section 2.0 provides information on how the national aircraft emission estimates were developed. This inventory effort was coordinated by the EPA's Office of Transportation and Air Quality (OTAQ) and EIAG. The appendixes were created to provide the supporting references from OTAQ.

2.0 DEVELOPMENT OF THE AIRCRAFT COMPONENT FOR THE NEI

2.1 How does this aircraft study fit into the NEI?

The NEI was developed to include all point, nonpoint (sometimes referenced as “area”), and mobile sources. The approaches used in the point and nonpoint source categories are documented in other reports. Table 2-1 summarizes the approaches used to estimate emissions from all nonroad sources included in the NEI program. Those source categories and years that are included in this report are noted in bold.

The scope of this inventory component of the NEI was to compile criteria and HAP emissions data for aircraft operating in United States air space. In this effort, national emission estimates were often developed as point sources for each airport. The methodologies used to estimate emissions are discussed in this report.

The target inventory area includes every state in the United States and every county within a state, including Washington, DC, Puerto Rico, and US Virgin Islands. There are no boundary limitations pertaining to traditional criteria pollutant nonattainment areas or to designated urban areas. The pollutants inventoried included all criteria pollutants (and the 188 HAPs identified in Section 112(b) of the CAA).

In addition to numerous specific chemical compounds, the list of 188 HAPs includes several compound groups [e.g., individual metals and their compounds, polycyclic organic matter (POM)]; the NEI includes emission estimates for the individual compounds wherever possible. Many of the uses of the NEI depend upon data (e.g., toxicity) for individual compounds within these groups rather than aggregated data on each group as a whole.

The intent in presenting the following emission inventory approach is to provide sufficient and transparent documentation such that states and local agencies can use these approaches, in conjunction with their specific local activity data to develop more accurate and comparable emission estimates in future submittals.

This documentation is not meant to provide an exhaustive analysis on the derivation of all the inputs. For example, an emission factor used for a national estimate may be given in the appendix, but the source test data that were evaluated to obtain this factor may not be presented or discussed. The goal of the documentation provided is to show in a brief and concise manner how a given estimate was derived.

Table 2-1a. Methods Used to Develop Emission Estimates for Onroad Vehicle Sources
(Years addressed in this report are noted in bold print)

Base Year(s)	Pollutant(s)	Geographic Area	Emission Estimation Method
2008	All Criteria, HAPs	US, Puerto Rico, Virgin Islands	Emission estimates for all pollutants were developed using EPA's National Mobile Inventory Model (NMIM), which uses MOBILE6 (specifically, M6203ChcOxFixNMIM.exe) to calculate onroad emission factors. Where States provided alternate onroad MOBILE6 inputs or VMT, these data replaced EPA default inputs. Default VMT is based on FHWA 2008 data and 2008 Census population estimates.
2005	All Criteria, HAPs	US, Puerto Rico, Virgin Islands	Emission estimates for all pollutants were developed using EPA's NMIM, which uses MOBILE6 to calculate onroad emission factors. Where States provided alternate onroad MOBILE6 inputs or VMT, these data replaced EPA default inputs. Default VMT is based on FHWA 2005 data and 2005 Census population estimates.
2002	All Criteria, HAPs	US, Puerto Rico, Virgin Islands	Emission estimates for all pollutants were developed using EPA's NMIM, which uses MOBILE6 to calculate onroad emission factors. Where States provided alternate onroad MOBILE6 inputs or VMT, these data replaced EPA default inputs. California-supplied emissions data which replaced default EPA emission estimates for this state. Default VMT is based on FHWA 2002 data and population data from 2000 Census.
2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	California	Emissions and VMT provided by California at county/vehicle type level; State-provided emissions expanded to county/SCC level by EPA.
2001	NH_3	California	Calculated at State/county/SCC level by month using MOBILE6 emission factors with State-provided VMT data.
2001	All Criteria	AL; CO; ME; MA; MS; OR; UT; VA; WV; Maricopa County, AZ; Hamilton County, TN	State-provided VMT grown to 2001; emissions calculated by EPA using MOBILE6 emission factors.
2001	All Criteria	Rest of US	Calculated at State/county/SCC level by month using MOBILE6 and FHWA-based VMT.
1999	All Criteria	AL; ME; MA; MS; UT; VA; WV; Maricopa County, AZ; Hamilton County, TN	Calculated at State/county/SCC level by month using MOBILE6; State-provided VMT data used.
1999	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	California	Emissions and VMT provided by California at county/vehicle type level; State-provided emissions expanded to county/SCC level by EPA.
1999	NH_3	California	Calculated at State/county/SCC level by month using MOBILE6 emission factors with State-provided VMT data.
1999	PM_{10} Exhaust	Colorado	PM_{10} emissions and VMT provided by State.

Table 2-1a. Methods Used to Develop Emission Estimates for Onroad Vehicle Sources
(Years addressed in this report are noted in bold print)

Base Year(s)	Pollutant(s)	Geographic Area	Emission Estimation Method
1999	VOC, NO_x, CO, SO_2, PM_{10} brake and tire wear, $PM_{2.5}$, NH_3	Colorado	Calculated at State/county/SCC level by month using MOBILE6; State-provided VMT data used.
1999	All Criteria	Oregon	Emissions and VMT provided by Oregon at county/vehicle type level; State-provided emissions expanded to county/SCC level by EPA.
1999	All Criteria	Rest of US, Puerto Rico, and US Virgin Islands	Calculated at State/county/SCC level by month using MOBILE6 and FHWA-based VMT.
1999	HAPs	California	HAP emissions and VMT provided by California at county/vehicle type level; emissions allocated to SCC level by EPA.
1999	HAPs	Rest of US, Puerto Rico, and US Virgin Islands	MOBILE6 emission factors calculated at State/county/SCC level by season; applied to FHWA-based VMT.
1997-1998	All Criteria	US	2-step linear interpolation at State/count/SCC level based on 1996 and 1999 State/count/SCC level data.
1990, 1996	HAPs	US	MOBILE6 emission factors calculated at State/county/SCC level by season; applied to Federal Highway Administration (FHWA)-based vehicle miles traveled (VMT).
1991-1995	All Criteria	US	Linear interpolation at State/count/SCC level based on 1990 and 1996 State/count/SCC level data.
1988-1989	All Criteria	US	Linear interpolation at State/count/SCC level based on 1987 and 1990 State/count/SCC level data.
1979-1986	All Criteria	US	Linear interpolation at State/count/SCC level based on 1978 and 1987 State/count/SCC level data.
1978, 1987, 1990, 1996, 2000	All Criteria	US	Calculated at State/county/source classification code (SCC) level by month using MOBILE6, no State data incorporated.
1970, 1975	All Criteria	US	Linear extrapolation at national vehicle type level based on 1978 and 1987 national data.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
NONROAD Categories			
Nonroad Gasoline, Diesel, LPG, CNG	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's National Mobile Inventory Model (NMIM), which incorporates NONROAD2008. Where states provided alternate NMIM nonroad inputs, these data replaced EPA default inputs.
	2005	VOC, NO_x, CO, SO_2, , PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's NMIM, which incorporates NONROAD2005. Where States provided alternate nonroad inputs, these data replaced EPA default inputs.
	2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's NMIM, which incorporates NONROAD2004. Where states provided alternate nonroad inputs, these data replaced EPA default inputs. State-supplied emissions data also replaced default EPA emission estimates.
	1999	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) an updated 1999 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. Replaced State-submitted data for California for all NONROAD model categories; Pennsylvania for recreational marine and aircraft ground support equipment, and Texas for select equipment categories.
	1996, 1997, 1998, 2000 & 2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated year-specific national and California inventories, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios and California county-to-state ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. California results replace the diesel equipment emissions generated from prior application of county-to-national ratios.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1990 and 1996 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1990 and 1996. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1990 county-level emissions to estimate 1991-1995 emissions.
	1990	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1990 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1986, 1988, & 1989	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1985 and 1990 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1985 and 1990. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1985 county-level emissions to estimate 1986-1989 emissions.
	1987	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for 1987 by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.
	1985	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1985 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1970, 1975, 1978, & 1980	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for all years by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1996, 1997, 1998, 1999, 2000, & 2001	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD. NH_3 emissions for California were also recalculated using updated diesel fuel consumption values generated for California-specific runs, and assuming the 1996 county-level distribution.
	1985 & 1990	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD.
	1987	NH_3	Obtaining 1987 national fuel consumption estimates from Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1970, 1975, 1978, & 1980	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1990, 1996, & 1999	HAPs	Speciation profiles applied to county VOC and PM estimates. Metal HAPs were calculated using fuel and activity-based emission factors. Some state data were provided and replaced national estimates. (2003)
Aircraft			
Commercial Aircraft	**2008**	**Criteria and HAPs**	**Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)**
	2002 and 2005	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) was run for criteria pollutants, VOC and PM emissions were speciated into HAP components. (2004)
	1990, 1996, 1999, 2000, 2001	VOC, NO_x, CO, SO_x	Input landing and take-off (LTO) data into FAA EDMS. National emissions were assigned to airports based on airport specific LTO data and BTS GIS data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2003)
General Aviation, Air Taxis	**2008**	**Criteria and HAPs**	**Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO for aircraft identified as Air taxis. (2010)** **Used FAA LTO data from TAF and OTAQ provided activity data for smaller airports derived from FAA 5010 master plans. EPA approved generic emission factors for criteria estimates. Speciation profiles were applied to VOC and PM estimates to get national HAP estimates. (2010)**

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
General Aviation, Air Taxis (Continued)	2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2002 emissions for approximately 4,000 largest airports were calculated via EDMS and SIP guidance and included in the 2005 NEI as point sources. Only airports in FAA's T100 and TAF databases were included. State point source submittals were incorporated.
	1978, 1987, 1990, 1996, 1999, 2000, 2001, & 2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to develop national HAP estimates. (2004)
	1990, 1996, 1999, & 2002	Pb	Used Department of Energy (DOE) aviation gasoline usage data with lead concentration of aviation gasoline. (2004)
	1996	NH_3	Applied NH_3 emissions factors to 1996 national jet fuel and aviation gasoline consumption estimates.
Military Aircraft	**2008**	**VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$**	**Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed. (2010)**
	2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2002 emissions were included in the 2005 NEI as point sources similar to other TAF reported data.
	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, 2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed.
	1970-1998	VOC, NO_x, CO, SO_X, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
Auxiliary Power Units and Ground Support Equipment	**2008**	**VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, HAPs**	**Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)**
	2002 and 2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, HAPs	Computed via NONROAD2005 model runs.
	1985-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using LTO operations data from the FAA. Estimation methods prior to 1996 reported in EPA, 1998.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Unpaved Airstrips[1]	1985-2001	PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Aircraft Refueling[1]	1985-2001	VOC	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Commercial Marine Vessel (CMV)			
All CMV Categories	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	OTAQ provided CAP emission estimates for all CMV categories. Note that the SCCs for this category have changed such that the Diesel category refers to smaller vessels (Category 1 and 2) using distillate fuels and the Residual category refers to larger (Category 3) vessels using a blend of residual fuels. Emissions were allocated to segments using GIS shapefiles and adjusted based on limited state data (2010)
	2008	HAPs	OTAQ's 2008 estimates were speciated into HAP components using SEPA profiles (2009)
CMV Diesel	2002 and 2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2001 Estimates carried over. Used state data when provided. (2004)
		HAPs	1999 Estimates carried over. Used state data when provided. (2004)
	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Used criteria emission estimates in the background document for marine diesel regulations for 2000. Adjusted 2000 criteria emission estimates for other used based on fuel usage. Emissions were disaggregated into port traffic and underway activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
	1996	NH_3	Applied NH_3 emissions factors to 1996 distillate and residual fuel oil estimates (i.e., as reported in EIA, 1996).
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
CMV Steam Powered	2005	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$, HAPs	2002 estimates grown to 2005 (2008).
	2002	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$, HAPs	2002 based estimates were developed for port and underway category 3 (C3) vessels as part of a rulemaking effort. Emissions were developed separately for near port and underway emissions. For near port emissions, inventories for 2002 were developed for 89 deep water and 28 Great Lake ports in the U.S. The Waterway Network Ship Traffic, Energy, and Environmental Model (STEEM) was used to provide emissions from ships traveling in shipping lanes between and near individual ports (2008)
	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Calculated criteria emissions based on EPA SIP guidance. Emissions were disaggregated into port traffic and under way activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, & 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
Military Marine	1997-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CMV Coal,[2] CMV, Steam powered, CMV Gasoline[2]	1997-1998	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CM Coal, CMV, Steam powered, CMV Gasoline, Military Marine	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Estimation methods reported in EPA, 1998.
Locomotives			
Class I, II, III and Yard operations	2008	VOC, NO_x, CO, PM_{10}, $PM_{2.5,}SO_x$ & HAPs	Criteria emission estimates were provided to EPA by ERTAC. These data were assigned to individual railway segments using DOT shapefiles and guidance from ERTAC. HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. (2010)

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Class I, Class II, Commuter, Passenger, and Yard Locomotives	1978, 1987, 1990, 1996, 1999, 2000, 2000, 2002, & 2005	VOC, NO_x, CO, PM_{10}, $PM_{2.5}$	Criteria pollutants were estimated by using locomotive fuel use data from DOE EIA and available emission factors. County-level estimates were obtained by scaling the national estimates with the rail GIS data from DOT. State data replaced national estimates. (2004)
	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, & 2005	SO_2	SO_x emissions were calculated by using locomotive fuel use and fuel sulfur concentration data from EIA. County-level estimates were obtained by scaling the national estimates with the county level rail activity data from DOT. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. County-level estimates were obtained by scaling the national estimates with the county level rail activity from DOT. State data replaced national estimates. (2004)
	1997-1998	NH_3	Grew 1996 base year emissions using EGAS growth indicators.
	1996	NH_3	Applied NH_3 emissions factors to diesel consumption estimates for 1996.
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Notes:

* Dates included at the end of Estimation Method represent the year that the section was revised.

1 Emission estimates for unpaved airstrips and aircraft refueling are included in the area source NEI, since they represent non-engine emissions.

2 National Emission estimates for CMV Coal and CMV Gasoline were not developed though states and local agencies may have submitted estimates for these source categories.

EPA, 1998. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Factors and Inventory Group, National Air Pollutant Emission Trends, Procedures Document, 1900–1996, EPA-454/R-98-008. May 1998.

2.2 What are Aircraft Sources?

The aircraft source category includes all aircraft types used for public, private, and military purposes. This includes four types of aircraft (EPA, 1992): 1) Commercial; 2) Air Taxis; 3) General Aviation; and 4) Military.

Commercial aircraft include those used for transporting passengers, freight, or both. Commercial aircraft tend to be larger aircraft powered with jet engines. Air Taxis (AT) carry passengers, freight, or both, but usually are smaller aircraft and operate on a more limited basis than the commercial carriers. General Aviation (GA) includes most other aircraft used for recreational flying and personal transportation. Aircraft that support business travel, usually on an unscheduled basis, are included in the category of general aviation.

The national AT and GA fleet includes both jet and piston-powered aircraft. Most of the AT and GA fleet are made up of piston powered aircraft, though smaller business jets can also be found in these categories. According to a 2008 Federal Aviation Administration GA and AT Activity Survey, 66% of all GA and AT activity are powered by piston-powered aircraft and 34% are jet (or turbine) driven. EPA has used this estimate as a national-scale default value in recently published studies investigating lead emissions from aviation sources (EPA, 2008). The piston powered aircraft tend to have higher VOC, PM, and CO emissions and lower NO_X emissions than larger jet-powered aircraft (EPA, 1992). Military aircraft cover a wide range of aircraft types such as training aircraft, fighter jets, helicopters, and jet- and a small number of piston powered planes of varying sizes.

It should be noted that this inventory effort also includes criteria and Hazardous Air Pollutants (HAP) emission estimates for aircraft Auxiliary Power Units (APU) 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.

2.3 What Pollutants are Included in the National Emission Estimates for Aircraft?

Emissions estimates were developed for all criteria pollutants including volatile organic compounds (VOC), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$) and hazardous air pollutants (HAP) (Cook, 1997; Cook, 1998; EPA/FAA, 2009). The HAPs that are included in the national aircraft inventory are shown in Table 2-2 and are based on available test data and accepted emission estimation procedures.

Table 2-2. Aircraft Pollutant List

1,3-Butadiene	Carbon Dioxide	Naphthalene
1-Methylnaphthalene*	Carbon Monoxide	Nitrogen Oxides
2,2,4-Trimethylpentane	Chrysene*	O-xylene*
2-Methylnaphthalene*	Cumene*	Phenanthrene*
Acenaphthene*	Dibenzo[a,h]Anthracene*	Phenol
Acenaphthylene*	Ethyl Benzene	PM_{10} Primary
Acetaldehyde	Fluoranthene*	$PM_{2.5}$ Primary
Acrolein	Fluorene*	Propionaldehyde
Anthracene*	Formaldehyde	Pyrene*
Benz[a]Anthracene*	Hexane*	Styrene
Benzene	Indeno[1,2,3-c,d]Pyrene*	Sulfur Dioxide
Benzo[a]Pyrene*	Lead	Toluene
Benzo[b]Fluoranthene*	Methane*	VOCs
Benzo[g,h,i,]Perylene*	Methanol*	Xylene
Benzo[k]Fluoranthene*	M-xylene*	

* Added to 2008 Inventory

2.4 How Were the Aircraft Emissions Estimated?

EPA has developed guidance for inventorying aircraft emissions associated with an aircraft's landing and takeoff (LTO) cycle. The cycle begins when the aircraft approaches the airport on its descent from cruising altitude, lands, taxis to the gate, and idles during passenger deplaning. It continues as the aircraft idles during passenger boarding, taxis back out onto the runway for subsequent takeoff, and ascent (climbout) to cruising altitude. Thus, the five specific operating modes in an LTO are (EPA, 1992): 1) Approach; 2) Taxi/idle-in; 3) Taxi/idle-out; 4) Takeoff; and 5) Climbout.

The LTO cycle provides a basis for calculating aircraft emissions. During each mode of operation, an aircraft engine operates at a fairly standard power setting for a given aircraft category. Emissions for one complete cycle are calculated using emission factors for each operating mode for each specific aircraft engine combined with the typical period of time the aircraft is in the operating mode.

On March 20, 2009, the EPA posted preliminary LTO data intended to be will use to calculate emissions for review prior to developing the aircraft inventory. State and local agencies were encouraged to review the materials posted at ftp://ftp.epa.gov/EmisInventory/2008_nei/ and provide comments on any necessary corrections to:

- Airport names and locations for approximately 20,000 airports to be included in the Emission Inventory System (EIS) facility inventory;

- Landing and Takeoff (LTO) information that will be used to estimate emissions for each airport;

- Aircraft/engine combinations to link to FAA LTO data including default assumptions and AircraftEngineCodeTypes for EIS submittals; and

- Lead estimates and lead estimation methodology.

This preliminary review by state, local, and tribal groups provided information that EPA used to improve EPA's work. EPA received comments from four states (i.e., Minnesota Pollution Control Agency - Environmental Analysis and Outcomes Division; New Jersey Department of Environmental Protection; Bureau of Air Management, Connecticut Department of Environmental Protection; and Wisconsin Department of Natural Resources (specifically related to Volk Field Air National Guard Base (VOK) in Juneau County Wittman Regional Airport (OSH)) and three local agencies (i.e., Mecklenburg County North Carolina; Ventura County California Air Pollution Control District (Specifically related to Oxnard (OXR), Camarillo (CMA) and Santa Paula (SZP); and - Regional Air Pollution Control Agency (Dayton and Montgomery County Ohio)).

Criteria emission estimates are presented here for four different aircraft types: commercial air carrier, air taxis, general aviation, and military. HAP emission estimates were developed for all aircraft types.

Emissions for commercial air carriers for which detailed aircraft-specific activity data were available, were calculated differently than the other three aircraft categories (See Figure 2-1). Criteria and HAP emissions were estimated for commercial aircraft by applying aircraft make and model (e.g., Boeing 747-200 series) specific LTO activity data from *FAA's Form 41, Schedules T100 and T100(f) Air Carrier Data to the FAA's Emissions and Dispersion Modeling System (EDMS), Version 5.1* (DOT, 2008). It should be noted that due to the reporting requirements of T-100, only commercial activities are included in the dataset, and therefore does not include activity data for non-air carrier applications such as general aviation and military. This distinction lead to a revision to EPA's original aircraft crosswalk table, also known as the aircraft engine type code, used to match aircraft to EDMS aircraft and to account for double counting between the T-100 data and the TAF data. In the revised crosswalk, aircraft that were previously considered general aviation and military based on aircraft model were changed to air taxi and commercial air carrier aircraft types based on the definition of air taxis (i.e., any aircraft that was not considered an air taxi was classified as an air carrier aircraft). The FAA reviewed the cross walk tables and made additional changes that moved some of the larger air taxis to the commercial air carrier category and some of the smaller commercial air carriers to the air taxi category. The revised crosswalk table is provided in an electronic file as supporting data for this study.

Emissions were calculated for each airport individually using airport specific mixing height. The national-scale default values for taxi in and out are seven and nineteen minutes, respectfully. It should be noted that EDMS incorporates the latest aircraft engine emission factors from the International Civil Aviation Organization Engine Exhaust Emissions Data Bank. The EDMS output includes organic HAPs, but not metals.

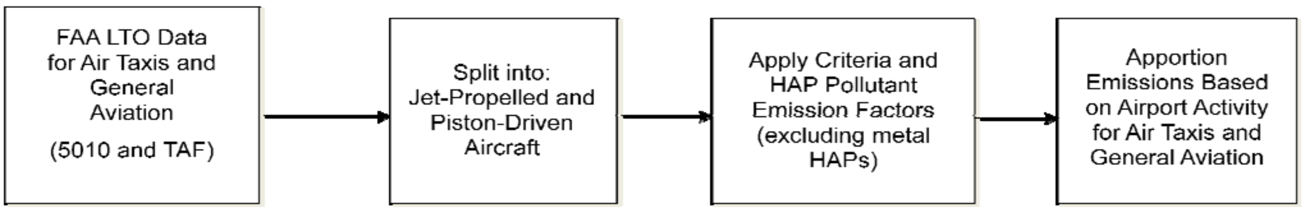

Figure 2-1. Procedures for Estimating Emissions from Commercial Air Carriers

Emissions for GSE and APU associated with commercial air carriers and air taxis for which T-100 data were available were estimated by EDMS, using the assumptions and defaults incorporated in the model. This is significant change from previous NEI year's emissions where GSE estimates came from the NONROAD model and APUs were not included in EPA's estimates. With EDMS, GSE that are assigned to an aircraft are given times (minutes per arrival, minutes per departure) based upon the type of service. For example, a fuel truck servicing a large commercial aircraft will have a different operating time than the same fuel truck servicing a commuter aircraft. All EDMS defaults for GSE duration and type (e.g., fuel truck, cabin service truck, baggage belt loader) were used. GSE emission factors used by EDMS are derived from EPA's NONROAD2005 model and are based on the following variables: fuel, brake horsepower and load factor. GSE engines burn gasoline, diesel, compressed natural gas (CNG), and liquefied petroleum gas (LPG). EPA has used a national-scale value to characterize engines type. The GSE engine distribution is shown below in Table 2-3. Like GSE, APU emissions are the product of operating time. The purpose of an aircraft APU is to provide power to start the main engines and run the heating, cooling, and ventilation systems prior to starting the main engines.

Table 2-3. National-Scale GSE Engine Distribution

GSE Engines Type	Percent of Total
Gasoline Fired, 4-Stroke	16.9
Liquefied Petroleum Gas (LPG) Fired	1.65
Compressed Natural Gas (CNG) Fired	1.25
Diesel Fired	80.2

Emissions of criteria pollutants for air taxis, general aviation, and military aircraft were calculated by combining aircraft operations data from FAA's *Terminal Area Forecasts (TAF) and 5010 Forms.* To avoid double counting between the T-100 data set and the TAF/5010 data, LTOs by airport and aircraft type were summed in the T-100 data and compared with data in the TAF/5010 data. If the TAF/5010 LTO estimates were larger than the T-100 estimates for a specified aircraft type then the T-100 values were subtracted from the TAF/5010 values. If the T-100 values were larger than the TAF values, then the TAF values were set to zero. A data set of adjusted TAF/5010 LTOs were provided to OTAQ where additional adjustments were made to address older data in the TAF and 5010 datasets and to incorporate other insights provided by FAA reviewers.

The TAF/5010 LTO data were dividing into jet and piston powered fractions based on the national observation that 66 percent of all general aviation and air taxi activities are associated with piston powered aircraft and the remaining 34 percent of general aviation and air taxi activities are associated with jet powered aircraft. The adjusted and split TAF/5010 activity data were applied to emission factors as appropriate (See Figure 2-2). It should be noted that EDMS calculates organic HAP emissions in the model (metal HAPs are currently not included in the EDMS output). HAP emission estimates for air taxis, general aviation, and military aircraft were estimated by applying speciation profiles to VOC or PM_{10} emissions estimates. The following equation was used (emission factor are included as Appendix A).

$$E_{ixj} = LTO_i \times FR_{pro\text{-}i} \times EF_{ij}$$

Where:

E_{ixj} = Emission estimate for aircraft type i equipped with engine type x and pollutant j (lbs/year)
LTO_i = Annual count of LTO cycles for aircraft type i
FR_x = Fraction of LTOs equipped with engine type x
EF_{ij} = Generic emission factor for aircraft type i equipped with engine type x and pollutant j (lbs/LTO)
i = Aircraft type (i.e., air taxi, general aviation, and military)
x = Engine type (i.e., jet or turboprop, and piston engine)
j = Criteria pollutant j

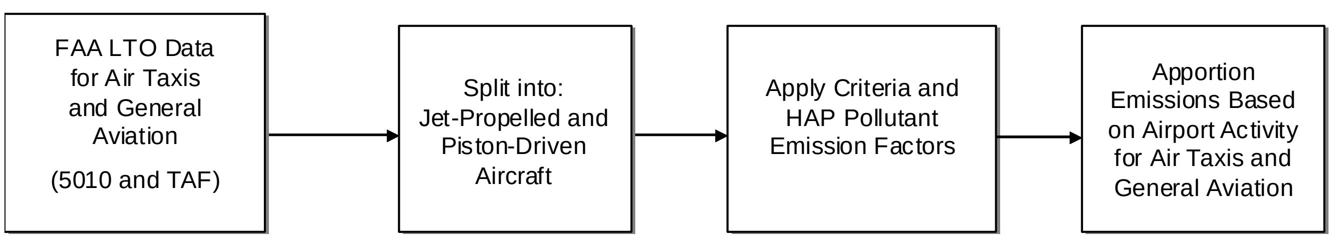

Figure 2-2. Procedures for Estimating Emissions from Commercial Air Taxis and General Aviation

Lead emission estimates were handled differently. Lead emissions are associated with leaded aviation fuel used in piston driven aircraft associated with general aviation. Lead emissions per LTO are calculated using the following equation:

$$Pb(tons) = (piston\text{-}engine\ LTO)\ (7.34\ g\ Pb/LTO)\ (0.95)\ /\ 907{,}180\ (g/ton)$$

Where the lead content of aviation gasoline is assumed to be 0.56 grams per liter or 2.12 grams per gallon.

In flight lead emissions were calculate based on national aviation gasoline consumption and similar assumptions noted above about lead fuel content and retention rates. Lead emissions associated with airport LTO activities were subtracted from the national fuel based lead emissions to approximate in flight lead emissions which were allocated to individual counties and noted with the code 777.

For additional details on EPA lead emission calculation procedures see Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory (included in Appendix B).

HAP Emission Estimates

As noted earlier, EDMS calculates organic HAP emissions for aircraft activity reported in the T-100 dataset. Representative HAP speciation profiles were used to estimate the individual chemical species for each aircraft type included in the TAF/5010 dataset. Profiles are used to split (or speciate) organic gases, hydrocarbons, and particulate matter emissions estimates into more individual HAP compounds using the following equation:

$$E_{ixj} = LTO_{ix} \times SP_{ixj}$$

Where:

E_{ixj} = Emission estimate for aircraft type i equipped with engine type x and pollutant j (tons/year)
LTO_{ix} = Annual count of LTO cycles for aircraft type i and engine type x
SP_{ixj} = Generic speciation profiles for aircraft type i equipped with engine type x and pollutant j (tons/LTO)
i = Aircraft type (i.e., air taxi, general aviation, and military)
x = Engine type (i.e., jet or turboprop, and piston engine)
j = Pollutant j

Appendix A contains the HAP profiles converted to emissions factors used for this 2008 inventory. In this version of the NEI aircraft emissions inventory the following corrections to the HAP emission estimates were made:

- Acenpthylene was removed from this inventory for SCC 2275050012.

- To avoid double counting total xylene emissions were removed if speciated xylene factors were also available.

2.5 How Were Emissions Allocated?

For the 2008 inventory, emissions were individually estimated for each airport. A GIS database obtained from the Bureau of Transportation Statistics (BTS) contained airport level data with latitude and longitude coordinates.

2.6 QA/QC

Given the significant methodological changes over previous inventory efforts, several quality checks were implemented to ensure that these data were developed and allocated in a clear and reproducible manner. Some of the quality checks implemented include the following:

Emissions allocations and estimations

- All original data importations and transcriptions into the database were double-checked for errors.
- All calculation methods and approaches were evaluated for technical soundness.
- All unit conversions and equations used to generate results were double-checked for errors.
- All sources of original data are referenced in the spreadsheet.
- Emission factors were compiled from a variety of sources. Each emission factor development methodologies were evaluated to identify the most accurate emission factor for use in this inventory effort.
- Emission sums were evaluated across activity types (e.g., Aircraft, APU, and GSE) to ensure they consistently mirror LTO activity levels.
- 2008 pollutants and emissions were checked against the 2005 inventory to identify any missing pollutants or major changes compared to previous inventories. Discrepancies were investigated and revisions were made as needed.
- The validity of SCC codes, FIP county codes, and pollutant codes were confirmed.
- The validity of Airport and plane identification codes were confirmed.

2.7 What are the Results?

Table 2-4 summarizes the emission estimates for Aircraft, ground support equipment and APUs for criteria pollutants. Table 2-5 summarizes the emission estimates for individual HAPs. Both tables aggregate the data for all states, including the District of Columbia. Note that the 2008 estimates do not include state submitted emissions data.

Table 2-4. Aircraft Criteria Emission Estimates 2008 (tons per year)

Pollutant	2008										
	Military (2275001000)	Commercial (2275020000)	GA, Piston (2275050011)	GA, Turbine (2275050012)	AT, Piston (2275060011)	AT, Turbine (2275060012)	GSE, Gas (2265008005)	GSE, LPG (2267008005)	GSE, CNG (2268008005)	GSE, Diesel (2270008005)	APU (2275070000)
CO	33,161.20	75,463.61	192,510.69	56,532.07	19,116.38	10,180.90	18,005.13	1,768.69	1,398.67	85,607.61	4,072.84
NO_X	284.92	102,561.46	1,041.55	1,911.11	465.64	2,274.10	1,927.90	189.38	149.76	9,166.44	2,841.72
PM_{10}-PRI	709.12	1,782.43	3,792.85	1,397.21	242.12	797.03	55.87	5.49	4.34	265.62	457.11
$PM_{2.5}$-PRI	92.60	1,776.37	493.07	181.64	44.81	103.65	53.63	5.27	4.17	254.97	457.11
SO_2	27.32	10,179.67	160.24	434.33	53.76	439.43	53.21	5.23	4.13	252.99	443.04
VOC	1,652.02	13,608.67	2,399.79	3,223.93	310.48	2,610.94	615.80	60.49	47.84	2,927.89	313.72

Table 2-5. Aircraft HAP Emission Estimates 2008 (tons per year)

Pollutant	2008										
	Military (2275001000)	Commercial (2275020000)	GA, Piston (2275050011)	GA, Turbine (2275050012)	AT, Piston (2275060011)	AT, Turbine (2275060012)	GSE, Gas (2265008005)	GSE, LPG (2267008005)	GSE, CNG (2268008005)	GSE, Diesel (2270008005)	APU (2275070000)
1,3-Butadiene	0.87	184.14	29.75	61.04	5.01	44.44					5.32
1-Methylnaphthalene	0.13	26.96		8.94	0.23	6.20					0.78
2,2,4-Trimethylpentane		0.69	1.09	1.55	0.03	0.51	8.95	0.88	0.69	42.54	
2-methylnaphthalene	0.11	22.48		7.45	0.20	5.17					0.65
Acenaphthene			0.36		0.17						
Acenaphthylene			2.03		0.93						
Acetaldehyde	2.21	466.29	18.82	154.57	11.97	113.00	2.43	0.24	0.19	11.57	13.47
Acrolein	0.02	37.70	1.82	88.61	0.04	32.72					
Anthracene			0.42	6.16E-04	0.19	3.52E-04					
Benz[a]Anthracene		6.09E-04	0.05	9.33E-05	0.02	5.32E-05					
Benzene	0.87	183.48	122.97	60.82	7.58	44.59	10.44	1.03	0.81	49.62	5.30
Benzo[a]Pyrene		4.52E-04	0.05	5.11E-05	0.02	2.91E-05					
Benzo[b]Fluoranthene		8.89E-04	0.06		0.03						
Benzo[g,h,i,]Perylene		8.11E-06	0.13	8.47E-06	0.06	4.83E-06					
Benzo[k]Fluoranthene		8.89E-04	0.06		0.03						
Chrysene		6.17E-04	0.05	8.69E-05	0.02	4.96E-05					

Table 2-5. Aircraft HAP Emission Estimates 2008 (tons per year) (Continued)

Pollutant	2008										
	Military (2275001000)	Commercial (2275020000)	GA, Piston (2275050011)	GA, Turbine (2275050012)	AT, Piston (2275060011)	AT, Turbine (2275060012)	GSE, Gas (2265008005)	GSE, LPG (2267008005)	GSE, CNG (2268008005)	GSE, Diesel (2270008005)	APU (2275070000)
Cumene	2.68E-05	0.05		0.11		0.04					
Ethyl Benzene	1.55E-03	2.68	44.63	6.30	1.05	2.32					
Fluoranthene		1.17E-03	0.45	1.29E-03	0.21	7.35E-04					
Fluorene			0.74		0.34						
Formaldehyde	6.36	1,343.45	81.67	445.41	38.06	327.87	7.20	0.71	0.56	34.23	38.82
Hexane			21.25		0.50						
Indeno[1,2,3-c,d]Pyrene		0.00	0.04		0.02						
Lead **			245.48		8.97						
Methane	0.01				18.96	14.79	14.61	1.44	1.14	69.47	
Methanol	0.02	27.78		65.31		24.11					
m-Xylene	0.14	26.44	0.36	1.58E-04	0.88	3.66	11.09	1.09	0.86	52.74	0.89
Naphthalene	0.28	54.17	21.11	20.42	5.05	13.86					1.71
O-xylene	0.08	15.56	2.03	9.30E-05	1.40	2.19	5.43	0.53	0.42	25.80	0.52
Phenanthrene		0.01	1.25	0.01	0.58	3.27E-03					
Phenol	0.01	11.17		26.27		9.70					
Propionaldehyde	0.38	79.35	1.82	26.30	2.29	19.45	1.48	0.15	0.11	7.04	2.29
Pyrene		1.42E-03	0.61	1.58E-03	0.28	8.99E-04					
Styrene	0.16	33.73	10.32	11.18	1.18	8.25					0.97
Toluene	0.33	70.07	315.76	23.23	8.87	16.77	17.77	1.75	1.38	84.50	2.02
Xylenes (Mixed Isomers)		4.85	177.92	19.04	4.18	6.21					

** The lead estimated provided above represent emissions at individual airports, for 2008, there is an additional 296 tons of lead emitted associated with the combustion of leaded aviation gasoline during in flight operations which is not attributed to airports.

2.8 Aircraft References

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Appendix A

Generic Aircraft Emission Factors/ Speciation Profiles

Commercial Aircraft Emission Factors			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			2.680E-03
VOC			2.934E-03
TOG			3.276E-03
NO_x			9.288E-03
CO			1.119E-02
SO_x			8.910E-04
PM_{10}			5.385E-04
$PM_{2.5}$			5.256E-04
Acetaldehyde	75070	CAA	1.400E-04
Acetone	67641		1.025E-05
Acetylene	74862		1.290E-04
Acrolein	107028	CAA	8.023E-05
Benzaldehyde	100527	IRIS	1.540E-05
Benzene	71432	CAA	5.507E-05
Benzo(a)anthracene	56553		1.297E-09
Benzo(a)pyrene	50328		9.621E-10
Benzo(b)fluoranthene	205992		1.892E-09
Benzo(ghi)perylene	191242		1.726E-11
Benzo(k)fluoranthene	207089		1.892E-09
1,3-Butadiene	101314	CAA	5.527E-05
1-Butene	101389		5.746E-05
Butyraldehyde	123728		3.899E-06
C14-Alkane	No CAS		6.094E-06
C15-Alkane	No CAS		5.799E-06
C16 Branched Alkane	No CAS		4.783E-06
C18-Alkane	No CAS		6.552E-08
C4-Benzene + C3-Aroald	No CAS		2.149E-05
C5-Benzene+C4-Aroald	No CAS		1.061E-05
Chrysene	218019		1.313E-09
Cis-2-Butene	514181		6.880E-06
Cis-2-Pentene	627203		9.042E-06
Crotonaldehyde	4170303		3.384E-05
1-Decene	872059		6.061E-06
Dibenzo(ah)anthracene	53703		2.551E-09
Dimethylnapthalenes	28804888		2.949E-06
Ethane	74840		1.707E-05
Ethylbenzene	100414	CAA	5.701E-06
Ethylene	74851		5.065E-04
Fluoranthene	206440		2.492E-09

Commercial Aircraft Emission Factors			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
Formaldehyde	50000	CAA	4.033E-04
Glyoxal	107222		5.950E-05
Heptene	25339564		1.435E-05
Hexadecane	544763		1.605E-06
1-Hexene	592416		2.411E-05
Indeno(1,2,3-cd)pyrene	193395		2.050E-09
Isopropylbenzene	98828	CAA	9.829E-08
Isovaleraldehyde	514863		1.048E-06
Methacrolein	78853		1.405E-05
Methanol	67561	CAA	5.913E-05
Methyl Glyoxal	78988		4.924E-05
1-Methyl Naphthalene	14120		8.092E-06
2-Methyl Naphthalene	91576	IRIS	6.749E-06
3-Methyl-1-Butene	563451		3.669E-06
4-Methyl-1-Pentene	131372		4.259E-07
2-Methyl-1-Butene	563462		4.587E-06
2-Methyl-2-Butene	513359		6.061E-06
2-Methylpentane	107835		1.337E-05
2-Methyl-1-Pentene	763291		1.114E-06
M-Ethyltoluene	620144		5.045E-06
M-Tolualdehyde	620235		9.108E-06
Naphthalene (gas phase)	91203	CAA	6.084E-06
Naphthalene (solid phase)	91203	CAA	1.260E-06
Napthalene	91203	CAA	1.772E-05
N-Decane	124185		1.048E-05
N-Dodecane	112403		1.514E-05
N-Heptadecane	629787		2.949E-07
N-Heptane	142825		2.097E-06
N-Nonane	111842		2.031E-06
N-Octane	111659		2.031E-06
1-Nonene	124118		8.059E-06
N-Pentadecane	629629		5.668E-06
N-Pentane	109660		6.487E-06
N-Propylbenzene	103651		1.736E-06
N-Tetradecane	629594		1.363E-05
N-Tridecane	629505		1.753E-05
N-Undecane	1120214		1.455E-05
Octene	111660		9.042E-06
O-Ethyltoluene	611143		2.130E-06

Commercial Aircraft Emission Factors			
Pollutant	CAS No.	CAA "187" or IRIS HAP?	Emission Factors (tons/LTO)
O-Tolualdehyde	529204		7.535E-06
1-Pentene	109671		2.542E-05
P-Ethyltoluene	622968		2.097E-06
Phenanthrene	85018		1.112E-08
Phenol	108952	CAA	2.378E-05
Propane	74986		2.555E-06
Propionaldehyde	123386	CAA	2.382E-05
Propylene	115071		1.485E-04
P-Tolualdehyde	104870		1.573E-06
Pyrene	121400		3.028E-09
Styrene	100425	CAA	1.012E-05
Toluene	108883	CAA	2.103E-05
Trans-2-Hexene	4050457		9.829E-07
Trans-2-Pentene	646048		1.176E-05
1,2,3-Trimethylbenzene	526738		3.473E-06
1,2,4-Trimethylbenzene	95636		1.147E-05
1,3,5-Trimethylbenzene	108678		1.769E-06
2,2,4-Trimethylpentane	540841	CAA	1.466E-06
Valeraldehyde	110623		8.027E-06
Xylene	1330207	CAA	1.032E-05

Air Taxi Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			4.37E-04
VOC			5.03E-04
TOG			5.06E-04
NO_x			3.88E-04
CO			1.81E-03
SO_x			8.12E-05
PM_{10}			3.017E-04
$PM_{2.5}$			3.922E-05
Acetaldehyde	75070	CAA	2.160E-05
Acetone	67641		1.583E-06
Acetylene	74862		1.992E-05
Acrolein	107028	CAA	1.238E-05
Anthracene	120127		1.331E-10
Benzaldehyde	100527	IRIS	2.377E-06
Benzene	71432	CAA	8.500E-06
Benzo(a)anthracene	56553		2.014E-11
Benzo(a)pyrene	50328		1.103E-11
Benzo(ghi)perylene	191242		1.829E-12
1,3-Butadiene	101314	CAA	8.531E-06
1-Butene	101389		8.869E-06
Butyraldehyde	123728		6.017E-07
C14-Alkane	No CAS		9.405E-07
C15-Alkane	No CAS		8.950E-07
C16 Branched Alkane	No CAS		7.383E-07
C18-Alkane	No CAS		1.011E-08
C4-Benzene + C3-Aroald	No CAS		3.317E-06
C5-Benzene+C4-Aroald	No CAS		1.638E-06
Chrysene	218019		1.876E-11
Cis-2-Butene	514181		1.062E-06
Cis-2-Pentene	627203		1.396E-06
Crotonaldehyde	4170303		5.224E-06
1-Decene	872059		9.355E-07
Dimethylnapthalenes	28804888		4.551E-07
Ethane	74840		2.635E-06
Ethylbenzene	100414	CAA	8.799E-07
Ethylene	74851		7.818E-05
Fluoranthene	206440		2.784E-10
Formaldehyde	50000	CAA	6.225E-05
Glyoxal	107222		9.183E-06

Air Taxi Emission Factors - Jet			
Pollutant	CAS No.	CAA "187" or IRIS HAP?	Emission Factors (tons/LTO)
Heptene	25339564		2.215E-06
Hexadecane	544763		2.478E-07
1-Hexene	592416		3.722E-06
Isopropylbenzene	98828	CAA	1.517E-08
Isovaleraldehyde	514863		1.618E-07
Methacrolein	78853		2.169E-06
Methanol	67561	CAA	9.127E-06
Methyl Glyoxal	78988		7.600E-06
1-Methyl Naphthalene	14120		1.249E-06
2-Methyl Naphthalene	91576	IRIS	1.042E-06
3-Methyl-1-Butene	563451		5.663E-07
4-Methyl-1-Pentene	131372		6.574E-08
2-Methyl-1-Butene	563462		7.079E-07
2-Methyl-2-Butene	513359		9.355E-07
2-Methylpentane	107835		2.063E-06
2-Methyl-1-Pentene	763291		1.719E-07
M-Ethyltoluene	620144		7.787E-07
M-Tolualdehyde	620235		1.406E-06
Napthalene	91203	CAA	2.736E-06
N-Decane	124185		1.618E-06
N-Dodecane	112403		2.336E-06
N-Heptadecane	629787		4.551E-08
N-Heptane	142825		3.236E-07
N-Nonane	111842		3.135E-07
N-Octane	111659		3.135E-07
1-Nonene	124118		1.244E-06
N-Pentadecane	629629		8.748E-07
N-Pentane	109660		1.001E-06
N-Propylbenzene	103651		2.680E-07
N-Tetradecane	629594		2.104E-06
N-Tridecane	629505		2.705E-06
N-Undecane	1120214		2.245E-06
Octene	111660		1.396E-06
O-Ethyltoluene	611143		3.287E-07
O-Tolualdehyde	529204		1.163E-06
1-Pentene	109671		3.924E-06
P-Ethyltoluene	622968		3.236E-07
Phenanthrene	85018		1.238E-09
Phenol	108952	CAA	3.671E-06

Air Taxi Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
Propane	74986		3.944E-07
Propionaldehyde	123386	CAA	3.676E-06
Propylene	115071		2.293E-05
P-Tolualdehyde	104870		2.427E-07
Pyrene	121400		3.401E-10
Styrene	100425	CAA	1.563E-06
Toluene	108883	CAA	3.246E-06
Trans-2-Hexene	4050457		1.517E-07
Trans-2-Pentene	646048		1.815E-06
1,2,3-Trimethylbenzene	526738		5.360E-07
1,2,4-Trimethylbenzene	95636		1.770E-06
1,3,5-Trimethylbenzene	108678		2.731E-07
2,2,4-Trimethylpentane	540841	CAA	1.915E-07
Valeraldehyde	110623		1.239E-06
Xylene	1330207	CAA	2.352E-06

Air Taxi Emission Factors - Piston			
Pollutant	CAS No.	CAA "187" or IRIS HAP?	Emission Factors (tons/LTO)
THC			7.750E-05
VOC			8.484E-05
TOG			9.474E-05
NO_x			7.900E-05
CO			1.407E-02
SO_x			7.500E-06
PM_{10}			3.015E-04
$PM_{2.5}$			3.920E-05
Acenaphthene	83329		2.201E-07
Acenaphthylene	208968		1.242E-06
Acetaldehyde	75070	CAA	5.874E-07
Acrolein	107028	CAA	5.684E-08
Anthracene	120127		2.563E-07
Benzene	71432	CAA	3.837E-06
Benzo(a)anthracene	56553		3.015E-08
Benzo(a)pyrene	50328		3.015E-08
Benzo(b)fluoranthene	205992		3.618E-08
Benzo(ghi)perylene	191242		7.839E-08
Benzo(k)fluoranthene	207089		3.618E-08
1,3-Butadiene	101314	CAA	9.285E-07
Chrysene	218019		3.015E-08
Ethylbenzene	100414	CAA	1.393E-06
Fluoranthene	206440		2.744E-07
Fluorene	86737		4.553E-07
Formaldehyde	50000	CAA	2.548E-06
Indeno(1,2,3-cd)pyrene	193395		2.412E-08
M-Xylene and P-Xylene	108383	CAA	2.201E-07
Naphthalene (gas phase)	91203	CAA	4.327E-07
Naphthalene (solid phase)	91203	CAA	4.432E-06
N-Hexane	110543		6.632E-07
O-Xylene	95476	CAA	1.242E-06
Phenanthrene	85018		7.658E-07
Propionaldehyde	123386	CAA	5.684E-08
Pyrene	121400		3.739E-07
Styrene	100425	CAA	3.221E-07
Toluene	108883	CAA	9.853E-06
2,2,4-Trimethylpentane	540841	CAA	3.394E-08

General Aviation Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			3.00E-04
VOC			2.73E-04
TOG			3.06E-04
NO_x			1.62E-04
CO			4.79E-03
SO_x			3.68E-05
PM_{10}			1.184E-04
$PM_{2.5}$			1.539E-05
Acetaldehyde	75070	CAA	1.309E-05
Acetone	67641		9.593E-07
Acetylene	74862		1.207E-05
Acrolein	107028	CAA	7.506E-06
Anthracene	120127		5.221E-11
Benzaldehyde	100527	IRIS	1.440E-06
Benzene	71432	CAA	5.152E-06
Benzo(a)anthracene	56553		7.903E-12
Benzo(a)pyrene	50328		4.327E-12
Benzo(ghi)perylene	191242		7.178E-13
1,3-Butadiene	101314	CAA	5.170E-06
1-Butene	101389		5.376E-06
Butyraldehyde	123728		3.647E-07
C14-Alkane	No CAS		5.700E-07
C15-Alkane	No CAS		5.425E-07
C16 Branched Alkane	No CAS		4.475E-07
C18-Alkane	No CAS		6.130E-09
C4-Benzene + C3-Aroald	No CAS		2.010E-06
C5-Benzene+C4-Aroald	No CAS		9.930E-07
Chrysene	218019		7.359E-12
Cis-2-Butene	514181		6.436E-07
Cis-2-Pentene	627203		8.459E-07
Crotonaldehyde	4170303		3.166E-06
1-Decene	872059		5.670E-07
Dimethylnapthalenes	28804888		2.758E-07
Ethane	74840		1.597E-06
Ethylbenzene	100414	CAA	5.333E-07
Ethylene	74851		4.738E-05
Fluoranthene	206440		1.092E-10
Formaldehyde	50000	CAA	3.773E-05
Glyoxal	107222		5.566E-06

General Aviation Emission Factors - Jet			
Pollutant	CAS No.	CAA "187" or IRIS HAP?	Emission Factors (tons/LTO)
Heptene	25339564		1.342E-06
Hexadecane	544763		1.502E-07
1-Hexene	592416		2.256E-06
Isopropylbenzene	98828	CAA	9.194E-09
Isovaleraldehyde	514863		9.807E-08
Methacrolein	78853		1.315E-06
Methanol	67561	CAA	5.532E-06
Methyl Glyoxal	78988		4.606E-06
1-Methyl Naphthalene	14120		7.570E-07
2-Methyl Naphthalene	91576	IRIS	6.313E-07
3-Methyl-1-Butene	563451		3.433E-07
4-Methyl-1-Pentene	131372		3.984E-08
2-Methyl-1-Butene	563462		4.291E-07
2-Methyl-2-Butene	513359		5.670E-07
2-Methylpentane	107835		1.250E-06
2-Methyl-1-Pentene	763291		1.042E-07
M-Ethyltoluene	620144		4.720E-07
M-Tolualdehyde	620235		8.520E-07
Naphthalene (gas phase)	91203	CAA	1.674E-06
Naphthalene (solid phase)	91203	CAA	5.571E-08
Napthalene	91203	CAA	1.658E-06
N-Decane	124185		9.807E-07
N-Dodecane	112403		1.416E-06
N-Heptadecane	629787		2.758E-08
N-Heptane	142825		1.961E-07
N-Nonane	111842		1.900E-07
N-Octane	111659		1.900E-07
1-Nonene	124118		7.539E-07
N-Pentadecane	629629		5.302E-07
N-Pentane	109660		6.068E-07
N-Propylbenzene	103651		1.624E-07
N-Tetradecane	629594		1.275E-06
N-Tridecane	629505		1.640E-06
N-Undecane	1120214		1.361E-06
Octene	111660		8.459E-07
O-Ethyltoluene	611143		1.992E-07
O-Tolualdehyde	529204		7.049E-07
1-Pentene	109671		2.378E-06
P-Ethyltoluene	622968		1.961E-07
Phenanthrene	85018		4.858E-10

General Aviation Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
Phenol	108952	CAA	2.225E-06
Propane	74986		2.391E-07
Propionaldehyde	123386	CAA	2.228E-06
Propylene	115071		1.390E-05
P-Tolualdehyde	104870		1.471E-07
Pyrene	121400		1.334E-10
Styrene	100425	CAA	9.470E-07
Toluene	108883	CAA	1.968E-06
Trans-2-Hexene	4050457		9.194E-08
Trans-2-Pentene	646048		1.100E-06
1,2,3-Trimethylbenzene	526738		3.249E-07
1,2,4-Trimethylbenzene	95636		1.073E-06
1,3,5-Trimethylbenzene	108678		1.655E-07
2,2,4-Trimethylpentane	540841	CAA	1.313E-07
Valeraldehyde	110623		7.509E-07
Xylene	1330207	CAA	1.612E-06

General Aviation Emission Factors - Piston			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			7.750E-05
VOC			7.524E-05
TOG			8.537E-05
NO_x			3.250E-05
CO			6.007E-03
SO_x			5.000E-06
PM_{10}			1.184E-04
$PM_{2.5}$			1.539E-05
Acenaphthene	83329		1.123E-08
Acenaphthylene	208968		6.339E-08
Acetaldehyde	75070	CAA	5.874E-07
Acrolein	107028	CAA	5.684E-08
Anthracene	120127		1.308E-08
Benzene	71432	CAA	3.837E-06
Benzo(a)anthracene	56553		1.539E-09
Benzo(a)pyrene	50328		1.539E-09
Benzo(b)fluoranthene	205992		1.846E-09
Benzo(ghi)perylene	191242		4.000E-09
Benzo(k)fluoranthene	207089		1.846E-09
1,3-Butadiene	101314	CAA	9.285E-07
Chrysene	218019		1.539E-09
Ethylbenzene	100414	CAA	1.393E-06
Fluoranthene	206440		1.400E-08
Fluorene	86737		2.323E-08
Formaldehyde	50000	CAA	2.548E-06
Indeno(1,2,3-cd)pyrene	193395		1.231E-09
M-Xylene and P-Xylene	108383	CAA	1.123E-08
Naphthalene (gas phase)	91203	CAA	4.327E-07
Naphthalene (solid phase)	91203	CAA	2.262E-07
N-Hexane	110543		6.632E-07
O-Xylene	95476	CAA	6.339E-08
Phenanthrene	85018		3.908E-08
Propionaldehyde	123386	CAA	5.684E-08
Pyrene	121400		1.908E-08
Styrene	100425	CAA	3.221E-07
Toluene	108883	CAA	9.853E-06
2,2,4-Trimethylpentane	540841	CAA	3.394E-08

Military Emission Factor			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			6.170E-04
VOC			6.815E-04
TOG			7.597E-04
NO_x			7.900E-05
CO			1.407E-02
SO_x			7.500E-06
PM_{10}			3.017E-04
$PM_{2.5}$			3.922E-05
Acetaldehyde	75070	CAA	3.245E-05
Acetone	67641		2.378E-06
Acetylene	74862		2.993E-05
Acrolein	107028	CAA	1.861E-05
Benzaldehyde	100527	IRIS	3.571E-06
Benzene	71432	CAA	1.277E-05
1,3-Butadiene	101314	CAA	1.282E-05
1-Butene	101389		1.333E-05
Butyraldehyde	123728		9.041E-07
C14-Alkane	No CAS		1.413E-06
C15-Alkane	No CAS		1.345E-06
C16 Branched Alkane	No CAS		1.109E-06
C18-Alkane	No CAS		1.519E-08
C4-Benzene + C3-Aroald	No CAS		4.984E-06
C5-Benzene+C4-Aroald	No CAS		2.461E-06
Cis-2-Butene	514181		1.595E-06
Cis-2-Pentene	627203		2.097E-06
Crotonaldehyde	4170303		7.848E-06
1-Decene	872059		1.405E-06
Dimethylnapthalenes	28804888		6.837E-07
Ethane	74840		3.958E-06
Ethylbenzene	100414	CAA	1.322E-06
Ethylene	74851		1.175E-04
Formaldehyde	50000	CAA	9.352E-05
Glyoxal	107222		1.380E-05
Heptene	25339564		3.328E-06
Hexadecane	544763		3.723E-07
1-Hexene	592416		5.591E-06
Isopropylbenzene	98828	CAA	2.279E-08
Isovaleraldehyde	514863		2.431E-07
Methacrolein	78853		3.259E-06

Military Emission Factor			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
Methanol	67561	CAA	1.371E-05
Methyl Glyoxal	78988		1.142E-05
1-Methyl Naphthalene	14120		1.876E-06
2-Methyl Naphthalene	91576	IRIS	1.565E-06
3-Methyl-1-Butene	563451		8.509E-07
4-Methyl-1-Pentene	131372		9.876E-08
2-Methyl-1-Butene	563462		1.064E-06
2-Methyl-2-Butene	513359		1.405E-06
2-Methylpentane	107835		3.100E-06
2-Methyl-1-Pentene	763291		2.583E-07
M-Ethyltoluene	620144		1.170E-06
M-Tolualdehyde	620235		2.112E-06
Napthalene	91203	CAA	4.110E-06
N-Decane	124185		2.431E-06
N-Dodecane	112403		3.510E-06
N-Heptadecane	629787		6.837E-08
N-Heptane	142825		4.862E-07
N-Nonane	111842		4.710E-07
N-Octane	111659		4.710E-07
1-Nonene	124118		1.869E-06
N-Pentadecane	629629		1.314E-06
N-Pentane	109660		1.504E-06
N-Propylbenzene	103651		4.026E-07
N-Tetradecane	629594		3.160E-06
N-Tridecane	629505		4.064E-06
N-Undecane	1120214		3.373E-06
Octene	111660		2.097E-06
O-Ethyltoluene	611143		4.938E-07
O-Tolualdehyde	529204		1.747E-06
1-Pentene	109671		5.895E-06
P-Ethyltoluene	622968		4.862E-07
Phenol	108952	CAA	5.515E-06
Propane	74986		5.926E-07
Propionaldehyde	123386	CAA	5.523E-06
Propylene	115071		3.445E-05
P-Tolualdehyde	104870		3.647E-07
Styrene	100425	CAA	2.348E-06
Toluene	108883	CAA	4.877E-06
Trans-2-Hexene	4050457		2.279E-07
Trans-2-Pentene	646048		2.727E-06

Military Emission Factor			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
1,2,3-Trimethylbenzene	526738		8.053E-07
1,2,4-Trimethylbenzene	95636		2.659E-06
1,3,5-Trimethylbenzene	108678		4.102E-07
Valeraldehyde	110623		1.861E-06

Appendix B

Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory

Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory
December 2010

Section 1. Introduction

The main purpose of this document is to describe the methods the Environmental Protection Agency (EPA) used to calculate airport lead (Pb) inventories for the 2008 National Emissions Inventory (NEI).[1] These methods focus on the development of approaches to estimate piston-engine aircraft activity at airports in the U.S. since the activity of this fleet is reported to the Federal Aviation Administration (FAA) as general aviation (GA) or air taxi (AT) activity – categories that also include jet-engine aircraft activity. The methods described here reflect improvements to the methods used in developing the airport-specific piston-engine aircraft inventories in the 2002 NEI and the 2005 NEI.

Background information regarding the use of leaded aviation gasoline (avgas) in piston-engine powered aircraft is available in other documents.[2,3] Briefly, most piston-engine aircraft operations fall into the categories of either GA or AT. Aircraft used in GA and AT activities include a diverse set of aircraft types and engine models and are used in a wide variety of applications.[4] Lead emissions associated with GA and AT aircraft stem from the use of one hundred octane low lead (100LL) avgas. The lead is added to the fuel in the form of tetraethyl lead (TEL). This lead additive helps boost fuel octane, prevent engine knock, and prevent valve seat recession and subsequent loss of compression for engines without hardened valves. Today, 100LL is the most commonly available type of aviation gasoline in the United States.[5] Lead is not added to jet fuel that is used in commercial aircraft, most military aircraft, or other turbine-engine powered aircraft. Lead emissions from the use of leaded avgas comprised 45% of the national inventory for emissions of lead in 2002.[6]

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[1] In this document '2008 NEI' refers to 2008 NEI version 1 (January 2011), available at http://www.epa.gov/ttn/chief/net/2008inventory.html

[2] EPA (2007) Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information. OAQPS Staff Paper. EPA-452/R-07-013 November 2007. pp 2-8 and 2-9.

[3] FAA William J. Hughes Technical Center http://www.tc.faa.gov/act4/insidethefence/2006/0609_06_AvFuels.htm

[4] Commercial aircraft include those used for scheduled service transporting passengers, freight, or both. Air taxis fly scheduled and for-hire service carrying passengers, freight or both, but they usually are smaller aircraft than those operated by commercial air carriers. General aviation includes most other aircraft (fixed and rotary wing) used for personal transportation, business, instructional flying, and aerial application.

[5] ChevronTexaco (2005) Aviation Fuels Technical Review. FTR-3. http://www.chevronglobalaviation.com/docs/aviation_tech_review.pdf

[6] U.S. Environmental Protection Agency (2008) EPA's Report on the Environment EPA/600/R-07/045F. Available at: http://www.epa.gov/roe

This document is organized into eight sections. Section 2 describes the data we use to calculate the national inventory for the amount of lead released to the air from the combustion of leaded avgas. Section 3 describes the landing and takeoff data we use to calculate airport-specific inventories for lead. Section 4 describes how we estimate landing and takeoff data for the airport facilities that do not report it to the FAA. Section 5 describes the estimate of landing and takeoff activity occurring at heliports in the U.S. Section 6 describes the methods used to calculate the airport-specific inventories for lead. Section 7 describes data that would be needed to improve the estimates of airport-specific inventories for lead and Section 8 describes the estimates of the amount of lead emitted in-flight that are in the 2008 NEI.

In this document, units of tons (i.e., U.S. short tons) are used when discussing the national and airport-specific lead inventory in order to be consistent with the manner in which the NEI reports inventories for lead and other pollutants. The unit of grams is used in describing the concentration of lead in avgas and in describing emission factors. Conversion factors are provided for clarity.

Section 2. Calculating the National Avgas Lead Inventory

Because lead is a persistent pollutant and accumulates in the environment, we include all lead emissions from piston-engine aircraft in the NEI – emissions occurring during the landing and take-off cycle at airports as well as emissions occurring at altitude.[7] To calculate the national avgas lead inventory, we use information provided by the U.S. Department of Transportation's (DOT's) Federal Aviation Administration (FAA) regarding the volume of leaded avgas consumed in the U.S. in 2008.[8] The U.S. Department of Energy's (DOE's) Energy Information Administration (EIA) provides information regarding the volume of leaded avgas produced in a given year. EPA has historically used the DOE EIA avgas fuel volume produced to calculate national lead inventories from the consumption of leaded avgas. However, since EPA uses DOT airport activity and aircraft data, we are using the DOT fuel volume data in the 2008 NEI to calculate the national lead inventory in order to use a consistent data source. In this document, when we refer to avgas fuel volume data it is data supplied by DOT, except where noted.

As demonstrated in the equation below, to calculate the annual emission of lead from the consumption of leaded avgas, we multiply the volume of avgas used by the concentration of lead in the avgas, minus the small amount of lead that is retained in the engine, engine oil and/or exhaust system. The volume of avgas used in the U.S. in 2008

[7] U.S. EPA, 2006. Air Quality: Criteria for Lead: 2006; EPA/600/R-5/144aF; U.S. Government Printing Office, Washington, DC, October, 2006.
[8] U.S. Department of Transportation Federal Aviation Administration Aviation Policy and Plans. FAA Aerospace Forecast Fiscal Years 2010-2030. p.99. Available at: http://www.faa.gov/data_research/aviation/aerospace_forecasts/2010-2030/media/2010%20Forecast%20Doc.pdf This document provides historical data for 2000-2008 as well as forecast data.

was 248,100,000 gallons.[9] The concentration of lead in avgas ([Pb] in the equation below) can be one of four levels (ranging from 0.14 to 1.12 grams of lead per liter) as specified by the American Society for Testing and Materials (ASTM). By far the most common avgas supplied is "100 Low Lead" or 100LL.[10,11] The maximum lead concentration specified by ASTM for 100LL is 0.56 grams per liter or 2.12 grams per gallon.[12] A fraction of lead is retained in the engine, engine oil and/or exhaust system which we currently estimate at 5%.[13]

For the 2008 NEI, the national estimate of lead emissions from the consumption of avgas was 551 tons (see equation below).

$$\frac{(248{,}100{,}000 \text{ gal})(2.12 \text{ g Pb/gal})(0.95)}{907{,}180 \text{ g/ton}} = 551 \text{ tons Pb}$$

As described above, DOE's EIA also provides estimates of the annual volume of leaded avgas produced in a given year. For 2008, the volume of avgas produced in the U.S. was 5,603 thousand barrels or 235,326,000 gallons.[14] Consumption of this volume of avgas equates to a national lead emissions estimate for this source of 522 short tons.

Section 3. Landing and Takeoff Data Sources and Uses

Airport-specific inventories require information regarding landing and takeoff (LTO) activity by aircraft type.[15] According to FAA records, there are approximately 20,000 airport facilities in the U.S., the vast majority of which are expected to have activity by piston-engine aircraft that operate on leaded avgas. Of these facilities, EPA's NEI has in the past, reported emissions of lead (and other criteria pollutants and

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[9] U.S. Department of Transportation Federal Aviation Administration Aviation Policy and Plans. FAA Aerospace Forecast Fiscal Years 2010-2030. p.99. Available at: http://www.faa.gov/data_research/aviation/aerospace_forecasts/2010-2030/media/2010%20Forecast%20Doc.pdf This document provides historical data for 2000-2008 as well as forecast data.

[10] ChevronTexaco (2005) Aviation Fuels Technical Review. FTR-3.

[11] The 2008 General Aviation Statistical Databook & Industry Outlook report by General Aviation Manufactures Association (GAMA) found that over 90% of avgas is 100LL.

[12] ASTM International (2005) Annual Book of ASTM Standards Section 5: Petroleum Products, Lubricants, and Fossil Fuels Volume 05.01 Petroleum Products and Lubricants (I): D 56 – D 3230.

[13] The information used to develop this estimate is from the following references: (a) Todd L. Petersen, Petersen Aviation, Inc, *Aviation Oil Lead Content Analysis*, Report # EPA 1-2008, January 2, 2008, available at William J. Hughes Technical Center Technical Reference and Research Library at http://actlibrary.tc.faa.gov/ and (b) E-mail from Theo Rindlisbacher of Switzerland Federal Office of Civil Aviation to Bryan Manning of U.S. EPA, regarding lead retained in engine, September 28, 2007.

[14] DOE Energy Information Administration. Fuel production volume data obtained from http://tonto.eia.doe.gov/dnav/pet/hist/mgaupus1A.htm accessed November 2006.

[15] An aircraft operation is defined as any landing or takeoff event, therefore, to calculate LTOs, operations are divided by two. Most data sources from FAA report aircraft activity in numbers of operations which, for the purposes of calculating lead emissions using the method described in this document, need to be converted to LTO events.

hazardous air pollutants) at 3,410 airports.[16] While the 3,410 airport facilities are among the most active in the U.S., they comprise only a small fraction of the total airport facilities where leaded avgas is used.

FAA's Office of Air Traffic provides a complete listing of operational airport facilities in the National Airspace System Resources (NASR) database. The electronic NASR data report, referred to here as the 5010 airport data report, can be generated from the NASR database and is available for download from the FAA website.[17] This report is updated every 56 days. EPA obtains airport information (including operations) for a subset of the facilities in the NASR database from FAA's Terminal Area Forecast (TAF) database that is prepared by FAA's Office of Aviation Policy and Plans.[18] The TAF database currently includes information for airports in FAA's National Plan of Integrated Airport Systems (NPIAS), which identifies airports that are significant to national air transportation. Approximately 500 of the airports that are in the TAF database have either an FAA air traffic control tower or an FAA contract tower where controllers count operations. The operations data from the control towers is reported to The Operations Network (OPSNET)[19] which is publically available in the Air Traffic Activity System (ATADS) database.[20] The operations data for the towered airports that is reported in OPSNET and ATADS is then reported to the TAF database. The operations data for the airports in the TAF database that do not have control towers represent estimates.[21] The operations supplied in the 5010 airport data report for facilities not reported in the TAF may be self-reported by airport operators through data collection accomplished by airport inspectors who work for the State Aviation Agency, or operations data can be obtained through other means.[22]

The 5010 airport data report supplies the date that the associated operations data represents.[23] Because airports that are not in the TAF database submit data voluntarily to FAA for the 5010 data report, many of the airports have operations data that represent data for years earlier than 2008. Nationally, GA and AT piston-engine operations have decreased in recent years,[24] therefore EPA did not use operations data from years prior to 2008 as it is reported. Instead, EPA multiplied the older GA and AT piston-engine data (Section 6 describes the method EPA used to calculate the number of piston-engine

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[16] These 3,410 facilities are the facilities for which the FAA's Terminal Area Forecast (TAF) database provides information regarding aircraft activity. The TAF database is prepared by FAA's Office of Aviation Policy and Plans and includes information for the airports in FAA's National Plan of Integrated Airport Systems (NPIAS). One of the goals of the NPIAS is to identify airports that are significant to national air transportation.

[17] http://www.faa.gov/airports_airtraffic/airports/airport_safety/airportdata_5010/

[18] http://aspm.faa.gov/main/taf.asp

[19] http://aspm.faa.gov/opsnet/sys/

[20] http://aspm.faa.gov/opsnet/sys/Airport.asp

[21] FAA's Terminal Area Forecast Summary (Fiscal Years 2009 – 2030), Appendix A (page 28) http://www.faa.gov/data_research/aviation/taf_reports/media/TAF%20Summary%20Report%20FY%2020 09%20-%202030.pdf

[22] In the absence of updated information from States, local authorities or Tribes, we are using the LTO data provided in the FAA database.

[23] The 12-month ending date on which annual operations data in the report is based.

[24] http://www.faa.gov/data_research/aviation_data_statistics/general_aviation/

operations from total GA and AT activity data) by scaling factors that were calculated by dividing the 2008 national amount of avgas produced by the national amount of avgas produced in the year the operations data represents.[25] A table with the scaling factors is provided in Appendix A. The national volume of avgas produced data comes from the DOE, EIA website and is available for 1981 – 2009.[26] For operations data older than 1981, EPA divided the 2008 national amount of avgas produced by the average of the national amount of avgas produced from 1981 – 1989. Jet engines do not use avgas, therefore EPA did not apply scaling factors to the turbine operations for data from years prior to 2008.

EPA also obtains operations data from the T-100 segment data from the Bureau of Transportation Statistics (BTS). The aircraft in the T-100 data are matched to aircraft in the FAA's Emission and Dispersion Modeling System (EDMS) using the crosswalk table developed for earlier versions of the NEI. Generally the T-100 data covers commercial air carrier operations, but some AT activities are included in the data set that would double count with the TAF data at the same airport. To correct for possible double counting, first the AT LTOs included in the T-100 data were compiled using the aircraft type data included in the aircraft make/models crosswalk.[27] The resulting aggregated LTOs were compared with the reported TAF LTOs for airports where there were overlaps. The T-100 AT LTOs were then subtracted from the TAF AT data to ensure that double counting was minimized. Note that if the T-100 AT value was larger than the TAF value, the TAF value was set to zero to eliminate the possibility of negative LTOs in the dataset.

The 2008 draft NEI was developed using the January 15, 2009 version of the 5010 airport data report. In that version of the report there were 19,925 airport facilities in the U.S. that had submitted data to the FAA. Among these 19,925 facilities, 99 facilities were not relevant for the purposes of estimating lead emissions because they were either listed as closed (85) or they were balloonports (14).[28] Therefore, lead inventories were needed for 19,826 facilities. In the January 15, 2009 version of the 5010 airport data report there were 5,654 airport facilities for which operations data were provided (many of which are facilities in FAA's TAF database).[29] There were 14,172 facilities in the 5010 airport data report for which there were no operations data.[30] As a

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[25] The FAA General Aviation and Air Taxi (Part 135) Activity Surveys (source of national level piston-engine operations data) are only available annually, starting in 1999. Because there are airports with operations data older than 1999, EPA used avgas product supplied data as a surrogate for piston-engine operations to estimate the change in piston-engine activity over the last three decades.

[26] http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=mgaupus1&f=A. DOT recently changed the way they estimate fuel consumption data, so while EPA used DOT data to determine the 2008 national avgas lead inventory, for the purpose of calculating these scaling factors EPA used DOE's data in order to have historical fuel data that is calculated in a consistent manner.

[27] The T-100 data does not specify that the operations data is air taxi in nature; however, in discussions with FAA, EPA determined that these flights are air taxi in nature and has assigned them in the 2008 NEI as such.

[28] Balloon craft do not use avgas

[29] Either Commuter, GA Itinerant, GA Local, or Air Taxi operations data, as these operations can be performed by piston-engine aircraft.

[30] No Commuter, GA Itinerant, GA Local, or Air Taxi operations data.

part of the review process for the draft 2008 NEI, EPA received updated airport data from states and also looked at more recent versions of the 5010 airport data report to update the status of airports, so the number of airports for which EPA estimated activity is slightly lower in the 2008 NEI than in the draft 2008 NEI. The following section of this document describes the method EPA used to estimate operations for the 14,132 airport facilities in the 2008 NEI that do not have reported activity data.

As described in Section 1, most piston-engine aircraft fall into the categories of either GA or AT. Some GA and AT activity is conducted by turboprop and turbojet aircraft which do not used leaded avgas. There are no national databases that provide airport-specific LTO activity data for piston-engine aircraft separately from turbojet and turboprop aircraft. The databases described above report total GA and AT activity conducted by both piston-engine and jet-engine aircraft. Part *(a)* in Section 6 describes how we estimate piston-engine LTOs at airports in the 2008 NEI.

Section 4. Estimating LTOs at the 14,132 Airport Facilities with No LTO Data

FAA has used regression models to estimate operations at facilities where operations data are not available.[31,32] In this work and other work, FAA identified characteristics of small towered airports for which there were statistically significant relationships with operations at these airports.[33] Regression models based on the airport characteristics were then used to estimate general aviation operations for a set of non-towered airports. The airport characteristics identified by FAA and used to estimate general aviation operations at small airports include: the number of aircraft based at a facility (termed 'based aircraft'), population in the vicinity of the airport, airport regional prominence, per capita income, region, and the presence of certificated flight schools.

In the 2000 report titled 'Model for Estimating General Aviation Operations at Non-towered Airports,' a model of GA annual activity was developed using information from small towered airports to explain GA activity at towered and non-towered airports. The model explained GA activity at the towered airports well (R^2 of 0.75) but produced higher estimates than state-supplied estimates for non-towered airports.[34]

The relevant data available in the 5010 airport data report for the purposes of estimating airport operations include: facility type (airport, balloonport, seaplane base, gliderport, heliport, stolport,[35] ultralight); number of GA aircraft based at each airport by

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[31] Federal Aviation Administration, Office of Aviation Policy and Plans, Statistics and Forecast Branch. July 2001. Model for Estimating General Aviation Operations at Non-towered Airports Using Towered and Non-towered Airport Data. Prepared by GRA, Inc.
[32] Mark Hoekstra, "Model for Estimating General Aviation Operations at Non-Towered Airports" prepared for FAA Office of Aviation Policy and Plans, April 2000.
[33] GRA, Inc. "Review of TAF Methods," Final Report, prepared for FAA Office of Aviation Policy and Plans under Work Order 45, Contract No. DTFA01-93-C-00066, February 25, 1998.
[34] The mean absolute difference between the model operations estimate and the state operations estimate was 16,940 operations.
[35] Stolport is an airport designed with STOL (Short Take-Off and Landing) operations in mind, normally having a short single runway.

type (glider, helicopter, jet engine, military, multi-engine, single engine, ultralight); operations data (air taxi, commercial, commuter, GA itinerant, GA local, military)[36]; and operations date (12-month ending date on which annual operations data is based). Census data was also merged with the 5010 airport data report to give population data for each airport's county.

Using the FAA work referenced above, we explored relationships among the airport data variables that best predicted aircraft activity (LTOs). We found that based aircraft was a highly significant and positive regressor to LTOs. Table 1 shows that for facilities that did not have LTO data in the January 15, 2009 version of the 5010 airport data report, 7,856 had based aircraft data while 6,316 did not have based aircraft data.[37, 38] Therefore, as described below, LTO estimates were derived using different methods depending on data availability.

Table 1: Contingency table describing the numbers of airport facilities that have or do not have LTO data and/or based aircraft data for airport facilities in the January 15, 2009 version of the 5010 airport data report

		HAVE LTO DATA		
		YES	**NO**	
HAVE BASED AIRCRAFT DATA	**YES**	4,872	7,856	**12,728**
	NO	782	6,316	**7,098**
		5,654	**14,172**	**19,826**

[36] As explained in footnote 15, an aircraft operation is defined as any landing or takeoff event, therefore, to calculate LTOs, operations are divided by two. The 5010 airport data report from FAA reports aircraft activity in numbers of operations which, for the purposes of calculating Pb emissions using the method described in the TSD, are converted to LTO events.

[37] As described in Section 3, the number of facilities with no LTO data changed slightly from the draft 2008 NEI to the 2008 NEI. In the 2008 NEI, of the facilities that did not have reported activity data, 7,837 facilities reported based aircraft data and 6,295 did not report based aircraft data.

[38] These numbers include data for the following types of facilities: airports, balloonports, seaplane bases, gliderports, heliports, stolports, and ultralights.

(a) Estimating LTOs at Facilities with Based Aircraft Data, but No LTO Data:

There are 6,414 facilities in the 2008 NEI (not including heliports) for which the 5010 airport data report supplies the number of based aircraft[39] but not activity data to which the regression equation (based aircraft vs. LTOs) could be applied. Using the 4,872 airports for which both LTO and aircraft data is known, the initial relationship found between based aircraft and LTOs was:

Equation 1:
LTOs = 2494 + 208*aircraft $R^2 = 0.55$

The FAA models found population to be another significant regressor. We used the population of the county in which the airport is located as the population variable. Adding county population to the model gave the following relationship:

Equation 2:
LTOs = 2204 + 194*aircraft + 0.0038*county population $R^2 = 0.56$

EPA received numerous comments to the docket on its Advance Notice of Proposed Rulemaking on Lead Emissions from Piston-Engine Aircraft Using Leaded Aviation Gasoline[40] indicating that aviation in Alaska is different than it is in the continental U.S. Commenters pointed out that in Alaska, 82% of communities are not accessible by road and rely on air transport for life sustaining goods and services.[41] Commenters also noted that Alaskans travel by air eight times more often per capita than those in the continental U.S. For those reasons, we added a dummy variable in equation 3 to identify whether or not an airport is located in Alaska. Because the relationship between based aircraft and LTOs is likely different for Alaskan airports than it is for airports that aren't in Alaska, we also added an interaction term to equation 3 (interaction of an airport being in Alaska and its sum of based aircraft).

Equation 3:
LTOs = 1937 + 205*aircraft + 0.0038*county population + 566*Alaska – 108*(AlaskaXaircraft)

$R_2 = 0.58$

After analyzing the data and plot for the data underlying equation 3, we found many airport facilities identified as commercial airports for which based aircraft was extremely low (i.e., less than 10), yet LTOs were quite high (i.e., anywhere from 100,000

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[39] Based aircraft for this purpose was limited to single- and multi-engine aircraft, helicopters, and ultralights since these aircraft types can use leaded avgas.
[40] U.S. Environmental Protection Agency (2010) Advance Notice of Proposed Rulemaking on Lead Emissions From Piston-Engine Aircraft Using Leaded Aviation Gasoline. 75 FR 22440 (April 28, 2010).
[41] Comments to the docket on EPA's Advance Notice of Proposed Rulemaking on Lead Emissions from Piston-Engine Aircraft Using Leaded Aviation Gasoline from the Alaska Air Carriers Association (dated 18 June 2010; comment number OAR-2007-0294-0323.1) and Alaska Governor Parnell (dated 25 August 2010; comment number OAR-2007-0294-0403.1).

to more than 200,000 LTOs/year).[42] These facilities were removed from the regression analysis. Additionally, for reasons described below, heliports were also removed from the regression. The resulting relationship was:

Equation 4:

LTOs = 1293 + 203*aircraft + 0.0019*county population - 473*Alaska – 144*(AlaskaXaircraft) $R^2 = 0.65$

When equation 4 was applied to the 6,414 airport facilities that report based aircraft data but not LTO activity, the resulting sum of LTOs was almost 15 million. EPA estimates that the number of LTOs at the airports that do not report activity data should approximate the number of LTOs from the bottom of the distribution of the set of airports that report activity data to the 5010 airport data report but that are not in the TAF database. The average number of LTOs per year from airports in the bottom 30% of the set of airports that report activity data to the 5010 airport data report but that are not in the TAF database is ~63 LTOs/year. Multiplying 63 by the number of airports that do not report activity data equals 549,050 LTOs.[43] Therefore, EPA used equation 4 to generate the distribution of LTOs at the individual airports that report based aircraft data but not activity data and then applied a scaling factor of 0.0356 to those LTOs to obtain the LTOs that are reported in the 2008 NEI.[44] The sum of the LTOs from this set of airports plus the sum of the LTOs at the airports that do not report either based aircraft or activity data (described below in section *(b)*) sum to 549,050 LTOs. These LTOs are all assigned to the GA, piston-engine category since they are assigned to smaller general aviation airports that are assumed to have little to no air taxi or jet aircraft activity.

Equation 4 and the scaling factor were used to estimate LTO activity for the 2008 NEI at airport facilities that report based aircraft data but not activity data.

(b) Estimating LTOs at Facilities with Neither Based-Aircraft Data nor LTO Data:

There are 2,260 facilities (not including heliports) for which the 5010 airport data report supplies neither the number of based aircraft nor activity data. In the absence of data to establish a relationship to airport activity, we assign a default value of LTOs to the GA, piston-engine category for each of these facilities.

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[42] From FAA's website, "Addresses for Commercial Service Airports", available at: http://www.faa.gov/airports_airtraffic/airports/planning_capacity/passenger_allcargo_stats/addresses/media/commercial_service_airports_addresses.xls

[43] This rounded number is calculated by multiplying 63.298 LTOs/year by 8,674, which is the number of airports that don't report activity data (6,414 don't report activity data and 2,260 facilities don't report activity or based aircraft data).

[44] The scaling factor was calculated by dividing 528,710 LTOs by 14,862,767 LTOS; the 528,710 LTOs are equal to 549,050 LTOs minus 20,340 LTOs (20,340 LTOs represent the sum of LTOs assigned to the 2,260 facilities that don't report either activity data or based aircraft data - the derivation of LTO estimates for these facilities is described in Section 4 *(b)*). The 14,862,767 LTOs are the sum of LTOs that result from applying equation 4 to the 6,414 facilities with based aircraft data but no activity data.

The default value was determined by evaluating GA LTOs that are reported at the set of 2,471 facilities that report activity data to the 5010 airport data report but that are not in the TAF set of airports. The average number of LTOs reported to the bottom ten percent of these facilities (when sorted by total GA LTOs) was 9. These facilities are assumed to most closely approximate the set of 2,260 facilities that do not report any based aircraft or LTO data; therefore, we assigned 9 LTOs to the GA, piston-engine category for these airport facilities for purposes of developing inventory estimates.

Section 5. Calculating LTOs at Heliports:

There were 5,559 heliport facilities in the January 15, 2009 FAA 5010 data report that were operational. Of those, only 92 (or 2%) reported LTO data, and of those, only 31 reported both based aircraft and LTO data. Because of the limited information regarding activity at heliports, some municipalities have hired contractors to survey activity in their local area.[45, 46]

The summary statistics for LTO data provided at the 92 operational heliports is presented in Table 2. These facilities report a wide range in activity from 3 LTOs/year to more than 18,000 LTOs/year. Some facilities clearly have significant helicopter traffic (i.e., thousands of LTOs/year) which is supported by the contractor summaries of heliport activity in the Washington Metropolitan area. The little data available to us suggests that the median helicopter activity is less than 200 LTOs/year. In the absence of more information on which to base estimates of LTO activity, we assigned 141 LTOs (the median of the reported heliport LTOs) to the GA category at all of the heliports which do not report LTO data. The piston-engine fraction developed in Section 6 is applied to the 141 LTOs resulting in 51 LTOs assigned to the GA, piston-engine category and 90 assigned to the GA, turbine-engine category. This is an area of significant uncertainty in the inventory and one for which EPA is seeking information from local agencies.

Table 2: Heliport LTO Data for those Reporting LTO Data in the January 15, 2009 Version of the 5010 Airport Data Report

18,250	Maximum LTOs
3	Minimum LTOs
1,123	Average LTOs
141	Median LTOs
50	Mode LTOs

[45] Executive Summary: Regional Helicopter System Plan, Metropolitan Washington Area, prepared by Edwards and Kelcey for the Metropolitan Washington Council of Governments, 2005.
[46] Alaska Aviation Emission Inventory, prepared by Sierra Research, Inc. for Western Regional Air Partnership, 2005.

Section 6. Methodology for Estimating Airport-Specific Lead Emissions

In 2008, EPA developed a method to calculate lead emissions at airports where piston-engine powered aircraft operate. [47] This method brings lead inventories into alignment with the manner in which other criteria pollutants emitted by aircraft are calculated. This method is described here with changes that were made from previous methods (i.e., the method used to develop the 2002 inventory) and applied in developing airport lead inventories for the 2008 NEI. In this section we first present the equation used to calculate lead emitted during the LTO cycle then we describe each of the components of the input data: we describe how we calculate piston-engine LTOs from data available in FAA databases, we describe the derivation of the emission factor for the amount of lead emitted during the LTO cycle, and we describe the estimate of the amount of lead retained in the engine and oil that we do not include in the amount of lead released to the air.

Historically, where aircraft specific activity data are available (such as T-100), aircraft gaseous and particulate matter (PM) emissions have been calculated through the FAA's EDMS.[48] This modeling system was designed to develop emission inventories for the purpose of assessing potential air quality impacts of airport operations and proposed airport development projects. However, EDMS has a limited number of piston-engine aircraft in its aircraft data and is currently not set up to calculate metal emissions and thus, it is not a readily available tool for determining airport lead inventories related to aircraft operations. In developing this approach to determine piston-engine aircraft lead emissions, EPA relied upon the basic methodology employed in EDMS. This requires as input the activity of piston-engine aircraft at a facility, fuel consumption rates by these aircraft during the various modes of the LTO cycle and time in each mode (taxi/idle-out, takeoff, climb-out, approach, and taxi/idle-in), the concentration of lead in the fuel and the retention of lead in the engine and oil. The equation used to calculate airport-specific lead emissions during the LTO cycle is below, followed by a description of each of the input parameters.

$$\text{LTO Pb (tons)} = \frac{\text{(piston-engine LTO)(avgas Pb g/LTO)(1-Pb retention)}}{\text{907,180 g/ton}}$$

(a) Calculating Piston-engine LTO:

Piston-engine LTOs are used to calculate emissions of lead that are assigned to the airport facility where the aircraft operations occur. An aircraft operation is defined as any landing or takeoff event, therefore, to calculate LTOs, operations are divided by two. Most data sources from FAA report aircraft activity in numbers of operations which, for the purposes of calculating lead emissions, need to be converted to LTO events. We

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[47] U.S. EPA (2008) Lead Emissions from the Use of Leaded Aviation Gasoline in the United States, Technical Support Document. EPA420-R-08-020. Available at: www.epa.gov/otaq/aviation.htm.
[48] EDMS available from http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/

describe here the method used to estimate the fraction of GA and AT LTOs at an airport that are conducted by piston-engine aircraft. These fractions are calculated separately (one fraction for GA and one for AT). These fractions are multiplied by total LTOs reported separately for GA and AT and then summed to arrive at the total LTOs conducted by piston-engine aircraft at an airport.

One use of the 2008 NEI is to identify sources of lead, including airports, that have inventories of 0.50 tons per year or more for the purposes of identifying locations where lead monitoring may be required to evaluate compliance with the National Ambient Air Quality Standard for Lead. To calculate the most airport-specific inventories for airports that may potentially exceed this inventory threshold, we used a more airport-specific surrogate for this subset of airports than the remainder of the airports where we applied national default averages described below.

We used the fraction of based aircraft at an airport that are single- or multi-engine to calculate the number of GA LTOs at an airport that were conducted by piston-engine aircraft. The data regarding the population of based aircraft at an airport is available for a subset of airports in the FAA 5010 master records data report described in Section 3. For example, if an airport reports 150 single-engine aircraft, 20 multi-engine aircraft and a total of 180 aircraft based at that facility, then the fraction of based aircraft we would use as a surrogate for piston-engine aircraft is 94% ((150+20)/180). We then multiply the total GA LTOs for that facility by 0.94 to calculate piston-engine LTOs.

We evaluated this surrogate by comparing the results of using it with piston-engine aircraft operations reported for airports that supply this information in master plans, airport layout plans, noise abatement studies and/or land use compatibility plans. We could rarely find data from the same year for comparison purposes; however, for the majority of airports, based aircraft and actual observed piston-engine aircraft activity agreed within ten percent.[49]

For the majority of airports in the 2008 NEI we used national average fractions of GA and AT LTOs conducted by piston-engine aircraft that were derived using FAA's General Aviation and Part 135[50] Activity Surveys – CY 2008 (GAATA).[51] Table 2.4 in the 2008 GAATA Survey reports that approximately sixty-six percent (66%) of all GA and AT LTOs are from piston-engine aircraft which use avgas, and about thirty-four

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[49] Documents used to evaluate the use of based aircraft include the following:

Airport Master Plan Update Prescott Municipal Airport (Ernest A Love Field) (2009) Available at: www.cityof**prescott**.net/_d/amp_tablecontents.pdf

Gillespie field Airport Layout Plan Update Narrative Report (2005) Available at: www.co.san-diego.ca.us/dpw/**airport**s/powerpoints/pdalp.pdf

Land Use Compatibility Plan for the Grand Forks International Airport (2006) Available at: www.gfk**airport**.com/authority/pdf/**land_use**.pdf

McClellan-Palomar Land Use Compatibility Plan (Amended March 4, 2010) Available at: www.ci.oceanside.ca.us/.../**McClellan-Palomar**_ALUCP_03-4-10_amendment.pdf

[50] On-demand (air taxi) and commuter operations not covered by Part 121

[51] The FAA GAATA is a database collected from surveys of pilots flying aircraft used for general aviation and air taxi activity. For more information on the 2008 GAATA, see Appendix A at http://www.faa.gov/data_research/aviation_data_statistics/general_aviation/CY2008/

percent (34%) are turboprop and turbojet powered which use jet fuel, such as Jet A. The LTO data in Table 2.4 in the 2008 GAATA Survey does not distinguish LTOs as GA or AT, and thus does not allow us derive separate piston activity fractions for GA and AT.

We are using the number of hours flown by piston versus turboprop or turbojet aircraft (reported in Table 1.4 in the 2008 GAATA Survey) to allow us to make separate estimates of the fraction of GA activity conducted by piston aircraft and the fraction of AT activity conducted by piston aircraft. We chose to use the fraction of hours flown by piston-engine aircraft as a surrogate to calculate the fraction of LTOs flown by piston aircraft since the overall (i.e., for GA and AT combined) piston percent of hours flown (66.4%) is very close to the percent of LTOs that are piston (65.7%). Table 1.4 of the 2008 GAATA presents the total hours flown by aircraft type and separates GA from AT. Seventy-three percent (73%) of all GA hours flown are by piston-engine aircraft while twenty-eight percent (28%) of all GA hours flown are by turboprop and turbojet powered aircraft.[52] Twenty-three percent (23%) of all AT hours flown are by piston-engine aircraft while seventy-seven percent (77%) of all AT hours flown are by turboprop and turbojet powered aircraft. Approximately 5,000 of the total 20,000 airport facilities in the U.S. are heliports at which only helicopters (rotocraft) operate. Therefore, EPA also calculated the percent of rotocraft hours flown that are conducted by piston-engine aircraft. Thirty-six percent (36%) of all GA rotocraft hours flown are by piston-engine rotocraft while sixty-four percent (64%) of all GA rotocraft hours flown are by turboprop and turbojet powered rotocraft. Two percent (2%) of all AT rotocraft hours flown are by piston-engine rotocraft while ninety-eight percent (98%) of all AT rotocraft hours flown are by turboprop and turbojet powered rotocraft. Table 3 identifies the piston and turbine fractions that were used in the absence of airport-specific information to calculate piston-engine operations at airports and heliports in the 2008 NEI.

Table 3: Piston and Turbine Activity Fractions used in the 2008 NEI

	Airports		**Heliports**	
	GA	**AT**	**GA**	**AT**
Piston Powered	72.5%	23.1%	36.1%	2%
Turbine Powered	27.5%	76.9%	63.9%	98%

[52] Numbers in the text may not add to 100% due to rounding; the percentages in Table 3 are the values we used to calculate the 2008 NEI.

(b) Calculating the Piston-engine Aircraft Emission Factor: Grams of Lead Emitted per LTO:

Piston-engine aircraft can have either one or two engines. EDMS version 5.0.2 contains information on the amount of avgas used per LTO for some single and twin-engine aircraft. The proportion of piston-engine LTOs conducted by single- versus twin-engine aircraft was taken from the FAA's GAATA Survey for 2008 (90% of LTOs are conducted by aircraft having one engine and 10% of LTOs by aircraft having two engines).[53] Since twin-engine aircraft have higher fuel consumption rates than those with single engines, a weighted-average LTO fuel usage rate was calculated to apply to the population of piston-engine aircraft as a whole. For the single-engine aircraft, the average amount of fuel consumed per LTO was determined from the six types of single piston-engine aircraft within EDMS.[54] This was calculated by averaging the single-engine EDMS outputs for fuel consumed per LTO using the EDMS scenario property of ICAO/USEPA Default - Times in Mode (TIM), with a 16 minute taxi-in/taxi-out time according to EPA's *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, 1992.[55] This gives a value of 16.96 pounds of fuel per LTO (lbs/LTO). The average single-engine fuel consumption rate was divided by the average density of 100LL avgas, 6 pounds per gallon (lbs/gal), producing an average fuel usage rate for single-engine piston aircraft of 2.83 gallons per LTO (gal/LTO). This same calculation was performed for the two twin-engine piston aircraft within EDMS, producing an average LTO fuel usage rate for twin-engine piston aircraft of 9.12 gal/LTO.

Using these single- and twin-engine piston aircraft fuel consumption rates, a weighted average fuel usage rate per LTO was computed by multiplying the average fuel usage rate for single-engine aircraft (2.83 gal/LTO) by the fleet percentage of single-engine aircraft LTOs (90%). Next, the twin-engine piston aircraft average fuel usage rate (9.12 gal/LTO) was multiplied by the fleet percentage of twin-engine aircraft LTOs (10%). By summing the results of the single- and twin-engine aircraft usage rates, the overall weighted-average fuel usage rate per LTO of 3.46 gal/LTO was obtained.

To calculate the emission factor, the concentration of lead in fuel is multiplied by the fuel consumption per LTO. The maximum lead concentration specified by ASTM for 100LL is 0.56 grams per liter or 2.12 grams per gallon. This amount of lead is normally added to assure that the required lean and rich mixture knock values are achieved. Multiplying this lead concentration in avgas by the weighted average fuel usage rate produces an overall average value of 7.34 grams of lead per LTO (g Pb/LTO) for piston-engines: 3.46 gal/LTO x 2.12 g Pb/gal = 7.34 g Pb/LTO.

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[53] The LTOs from the categories of 1-engine fixed wing piston, piston rotocraft, experimental total, and light sport were summed to determine the total number of single-engine piston aircraft LTOs.
[54] EPA understands that EDMS 5.0.2 has a limited list of piston-engines, but these are currently the best data available.
[55] U.S. EPA, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA-450/4-81026d (Revised), 1992.

(c) Retention of Lead in Engine and Oil (1-Pb Retention):

Data collected from aircraft piston-engines operating on leaded avgas suggests that about 5% of the lead from the fuel is retained in the engine and engine oil.[56] Thus the emitted fraction is 0.95. This information is used in calculating airport-specific lead inventories and will be used to develop future national estimates of lead emitted from the consumption of leaded avgas.

Applying these parameters in the equation above yields the following equation:

$$\text{Pb(tons)} = \frac{\text{(piston-engine LTO) (7.34 g Pb/LTO) (0.95)}}{\text{907,180 g/ton}}$$

which simplifies to:

$$\text{Pb(tons)} = \text{(piston-engine LTO)}\ (7.7 \times 10^{-6})$$

Where piston-engine LTO[57] = (GA LTO x 0.725) + (AT LTO x 0.231)

(d) Estimating Lead Emissions from Piston-Engine Helicopters:

The emission factor for helicopters (g Pb/LTO) was determined in the same manner as described above for piston-engine fixed-wing aircraft. The concentration of lead in avgas (2.12 g/gal) was multiplied by the weighted average fuel usage rate for four types of Robinson helicopter engines.[58] This produced an overall average emission factor of 6.60 grams of lead per LTO (g Pb/LTO) for piston-engine powered helicopters.

There are no national databases that provide heliport-specific LTO activity data for piston-engine powered helicopters separately from turbine-engine powered helicopters. The 2008 FAA GA and Part 135 Activity (GAATA) Survey reports that approximately 36% of all GA helicopter hours flown are by piston-engine aircraft which use avgas, and about 64% are by turbine-engine powered which use jet fuel (which does

[56] The information used to develop this estimate is from the following references: (a) Todd L. Petersen, Petersen Aviation, Inc, *Aviation Oil Lead Content Analysis*, Report # EPA 1-2008, January 2, 2008, available at William J. Hughes Technical Center Technical Reference and Research Library at http://actlibrary.tc.faa.gov/ and (b) E-mail from Theo Rindlisbacher of Switzerland Federal Office of Civil Aviation to Bryan Manning of U.S. EPA, regarding lead retained in engine, September 28, 2007.

[57] This equation for piston-engine LTOs only applies to non-heliport facilities. See the text immediately below for equations for calculating piston-engine LTOs and Pb emissions at heliports.

[58] This was done using the following 4 engine types in EDMS 5.1: Robinson R22 IO-320-D1AD; Robinson R22 IO-360-B; Robinson R22 O-320; Robinson R22 TSIO-360C. The fuel consumption rates were: Robinson R22 IO-320-D1AD – 5.546 g Pb/LTO; Robinson R22 IO-360-B – 5.973 g Pb/LTO; Robinson R22 O-320 – 6.276 g Pb/LTO; Robinson R22 TSIO-360C – 8.604 g Pb/LTO.

not contain lead).[59] The 2008 FAA GAATA Survey reports that approximately 2% of all AT helicopter hours flown are by piston-engine aircraft which use avgas, and about 98% are by turbine-engine powered rotocraft. We expect the fraction of helicopter activity conducted by piston-engines to vary by heliport with some facilities having no piston-engine powered helicopter activity and some hosting mainly or only piston-engine powered helicopters. However, in the absence of heliport-specific data, the national default estimates of 36% for GA and 2% for AT from the GAATA Survey were used. Therefore, to calculate piston-engine aircraft LTO as input for this equation, the helicopter GA LTOs were multiplied by 0.36 and helicopter AT LTOs were multiplied by 0.02.

Lead emitted at the heliport facility was calculated for the 2008 NEI using either the LTO data provided in FAA databases or the estimate LTO activity in the following equation (i.e., 141 LTOs):

$$\text{Pb(tons)} = \frac{\text{(piston-engine helicopter LTO) (6.60 g Pb/LTO) (0.95)}}{\text{907,180 g/ton}}$$

which simplifies to:

$$\text{Pb(tons)} = \text{(piston-engine helicopter LTO)} \ (6.9 \text{ X } 10^{-6})$$

Where piston-engine helicopter LTO = (Helicopter GA LTO x 0.36) + (Helicopter AT LTO x 0.02)

Section 7. Improving Airport-specific Lead Emissions Estimates

There are refinements to the methods described here that would improve airport-specific inventories, most of which involve acquiring airport- and aircraft-specific input data. The following information describes data inputs that could be used to generate airport lead inventories tailored to specific airports or otherwise improve the estimates using currently available data. State and local authorities might have, or be able to collect, better information for some of these key data inputs.

State and local agencies might have access to airport-specific data that would improve the national estimates of lead emissions per LTO. These improvements largely involve replacing national average or default values with airport-specific data on the activity of piston-engine aircraft. Three key data inputs are:

[59] The FAA GAATA is a database collected from surveys of pilots flying aircraft used for general aviation and air taxi activity. For more information on the GAATA, see Appendix A at http://www.faa.gov/data_statistics/aviation_data_statistics/general_aviation/

1) Airport-specific LTO activity for piston-powered aircraft, including the fraction of piston-engine activity conducted by single- versus twin-engine aircraft. Some airport facilities collect this information and states may use these data to calculate airport-specific lead inventories. The activity data should be current and updated on a regular schedule so that the data represents the inventory year as closely as possible.
2) The time spent in each mode of the LTO cycle. EPA uses the EDMS scenario property of ICAO/USEPA Default - Times in Mode, with a 16 minute taxi-in/taxi-out time according to EPA's Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, 1992. While some local authorities have confirmed that these are the relevant times in mode at their airports for piston aircraft, the applicability of these times in mode will vary by airport. EPA has learned that one of the important factors in piston aircraft operation that is currently not included in the time in mode or emissions estimates is the time and fuel consumption during the pre-flight run-up checks conducted by piston-engine aircraft prior to takeoff.
3) Other data inputs for the airport-specific lead inventory calculation for which states or local authorities may provide airport-specific information include the concentration of lead in the avgas supplied at an airport, and the fraction of lead in fuel that is retained in the engine and oil, and aircraft-specific fuel consumption rates by the piston-engine aircraft in specific modes of operation.

The accuracy of the based aircraft data on which equation 4 is modeled can be improved. FAA recognizes the need to improve the integrity of the 5010 data report based-aircraft counts for all of the GA airports and reliever airports in the NPIAS and is currently in the process of improving the data collection and submission methods to accomplish this task.[60]

Section 8. Lead emitted in flight (i.e., outside the LTO cycle):

Lead emissions, especially those at altitude, undergo dispersion and eventually deposit to surfaces, and lead deposited to soil and water can remain available for uptake by plants, animals and humans for long periods of time. Because lead is a persistent pollutant, we are including all lead emissions – at airports and in-flight – in the NEI.[61]

For inventory purposes, lead emitted outside the LTO cycle occurs during aircraft cruise mode and portions of the climb-out and approach modes above the mixing height (typically 3,000 ft[62]). This part of an aircraft operation emits lead at various altitudes as well as close to and away from airports. Because the precise area of lead emission and deposition is not known for these flights, EPA is using a simplistic approach to allocate

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[60] National Based Aircraft Inventory Program: http://www.basedaircraft.com/public/FrequentlyAskedQuestions.aspx, accessed 2/17/2009

[61] U.S. EPA, 2006. Air Quality: Criteria for Lead: 2006; EPA/600/R-5/144aF; U.S. Government Printing Office, Washington, DC, October, 2006.

[62] According to EPA's *Procedurees for Emission Inventory Preparation, Volume IV: Mobile Sources, 1992.*

these emissions for the purposes of the 2008 NEI. A brief explanation of the nature of GA flights is provided here for context regarding emissions of lead in-flight.

FAA categorizes GA flights as either local area or itinerant operations and this distinction plays a role in the area over which lead is emitted. Local operations are those activities performed by aircraft operating in the local traffic pattern or within sight of the airport, aircraft executing simulated instrument approaches or low passes at the airport, and/or aircraft operating to or from the airport in a designated practice area located within a 20-mile radius of the airport. Local operations are common for GA aircraft. This includes applications such as recreational, proficiency and instructional flying as well as many common general aerial support tasks. Emissions during local flying are more likely to influence air and soil concentrations of lead in the vicinity of the airport because they occur near the airport, often at altitudes below the mixing height.

Itinerant operations are all operations other than those described above as local operations. An itinerant aircraft operation usually is one in which the aircraft departs from one airport and lands at a different airport. Depending on air time and distance, an itinerant flight is much more likely to involve departing the local flying area of the originating airport and climbing to altitudes above the mixing height. It is reasonable then, to generally expect that lead emitted outside the LTO cycle during itinerant operations, in contrast with local operations, will be more widely dispersed and at greater distances from the airport.

The portion of the national avgas lead emitted in flight (i.e., outside the LTO cycle) is calculated by subtracting the sum of airport facility lead inventories from the national avgas lead inventory. Even though FAA collects and reports information regarding the fraction of GA operations that are local and itinerant, there is no practical method to assign in-flight lead emissions to small geographic areas such as airports or census tracts. And similar data is not available for AT operations, a portion of which are conducted by piston-engine aircraft. Since the average duration of a piston-engine aircraft flight is approximately an hour, an itinerant flight can traverse county lines. Therefore, given the current data available, the best approach is to assign the out-of-LTO cycle lead to the state where the flight originated.

In the 2008 NEI EPA allocated lead emissions that are calculated as being outside the LTO cycle to states based on the state-specific fraction of national GA and AT piston-engine LTO activity. The state-specific fractions were calculated by multiplying the percent of GA and AT piston-engine LTO activity in each state by 296 tons, which is the amount of lead we currently estimate is emitted outside of the LTO cycle nationwide. Table 4 presents the total GA and AT piston-engine LTOs by state, the state-specific faction of national GA and AT piston-engine LTO activity, and the out-of-LTO lead emissions assigned to each state.

Table 4: Out-of-LTO Lead Emissions by State

STATE	Total GA and AT Piston LTOs	Percent of National GA and AT Piston LTOs (by state)	Out of LTO Pb emissions (tons)
AK	660,133	2.0%	5.86
AL	671,026	2.0%	5.96
AR	638,875	1.9%	5.68
AZ	1,430,302	4.3%	12.71
CA	3,881,357	11.6%	34.48
CO	780,426	2.3%	6.93
CT	226,807	0.7%	2.01
DC	28,833	0.1%	0.26
DE	84,617	0.3%	0.75
FL	2,751,015	8.3%	24.44
GA	750,876	2.3%	6.67
HI	138,432	0.4%	1.23
IA	281,961	0.8%	2.50
ID	430,812	1.3%	3.83
IL	920,908	2.8%	8.18
IN	566,583	1.7%	5.03
KS	459,720	1.4%	4.08
KY	280,378	0.8%	2.49
LA	622,011	1.9%	5.53
MA	714,159	2.1%	6.34
MD	436,861	1.3%	3.88
ME	228,302	0.7%	2.03
MI	880,818	2.6%	7.82
MN	647,876	1.9%	5.76
MO	389,551	1.2%	3.46
MS	461,383	1.4%	4.10
MT	270,311	0.8%	2.40
NC	743,004	2.2%	6.60
ND	214,139	0.6%	1.90
NE	221,681	0.7%	1.97
NH	173,355	0.5%	1.54
NJ	466,961	1.4%	4.15
NM	309,657	0.9%	2.75
NV	298,712	0.9%	2.65
NY	999,738	3.0%	8.88
OH	1,180,583	3.5%	10.49
OK	575,402	1.7%	5.11
OR	596,730	1.8%	5.30
PA	954,839	2.9%	8.48

PR	80,728	0.2%	0.72
RI	45,348	0.1%	0.40
SC	506,650	1.5%	4.50
SD	228,198	0.7%	2.03
TN	535,913	1.6%	4.76
TX	2,422,722	7.3%	21.52
UT	299,471	0.9%	2.66
VA	502,559	1.5%	4.46
VI	25,763	0.1%	0.23
VT	88,318	0.3%	0.78
WA	1,189,142	3.6%	10.56
WI	778,320	2.3%	6.91
WV	143,393	0.4%	1.27
WY	106,190	0.3%	0.94

For additional information or if you have questions regarding the methods described in this document, please contact Meredith Pedde (pedde.meredith@epa.gov) or Marion Hoyer (hoyer.marion@epa.gov).

Supplemental Table 1

Table A-1: Scaling factors

Year	U.S. Product Supplied of Aviation Gasoline (Thousand Barrels)[63]	Ratio of 2008 to Year X
Before 1981[64]		0.57
1981	11,147	0.50
1982	9,307	0.60
1983	9,444	0.59
1984	8,692	0.64
1985	9,969	0.56
1986	11,673	0.48
1987	9,041	0.62
1988	9,705	0.58
1989	9,427	0.59
1990	8,910	0.63
1991	8,265	0.68
1992	8,133	0.69
1993	7,606	0.74
1994	7,555	0.74
1995	7,841	0.71
1996	7,400	0.76
1997	7,864	0.71
1998	7,032	0.80
1999	7,760	0.72
2000	7,188	0.78
2001	6,921	0.81
2002	6,682	0.84
2003	5,987	0.94
2004	6,189	0.91
2005	7,006	0.80
2006	6,626	0.85
2007	6,258	0.90
2008	5,603	1.00

[63] Data from the Energy Information Administration's (EIA's) table, "U.S. Product Supplied of Aviation Gasoline (Thousand Barrels)." Available at: http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=mgaupus1&f=A Accessed August 25, 2010.

[64] EIA does not have data for volumes of avgas product supplied for years earlier than 1981. To calculate the scaling factor to use for activity data from years before 1981, we used the ratio of 2008 avgas volume product supplied to the average avgas volume supplied from 1981 to 1989.

Appendix A-3

Nonroad 2008 Inventory Documentation for the Emissions Inventory Methodology for Commercial Marine Vessels, Locomotives, and Aircrafts

- Documentation of the Commercial Marine Vessel Component of the National Emissions Inventory Methodology
- Documentation of the Locomotive Component of the National Emissions Inventory Methodology
- Documentation of the Aircraft Component of the National Emissions Inventory Methodology

ERG No.: 0245.02.302.001
Contract No.: EP-D-07-097

Documentation for the Commercial Marine Vessel Component of the National Emissions Inventory

Methodology

Prepared by:

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March 30, 2010

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1.0 INTRODUCTION

1.1 What is the National Emission Inventory?

The National Emission Inventory (NEI) is a comprehensive inventory covering all anthropogenic sources of criteria pollutants and hazardous air pollutants (HAPs) for all areas of the United States. The NEI was created by the U.S. Environmental Protection Agency's Emission Inventory and Analysis Group (EIAG) in Research Triangle Park, North Carolina. The NEI will be used to support air quality modeling and other activities. To this end, the EPA established a goal to compile comprehensive emissions data in the NEI for criteria and HAPs for mobile, point, and nonpoint sources. This report presents an overview of how emission estimates for the commercial marine vessel (CMV) component of the 2008 NEI was compiled.

1.2 Why Did the EPA Create the NEI?

The Clean Air Act (CAA), as amended in 1990, includes mandates for the EPA related to criteria and hazardous air pollutants. The CAA defines criteria pollutants as being one of the following air pollutants:

- Carbon monoxide (CO);
- Sulfur oxides (SO_x);
- Nitrogen oxides (NO_x);
- Ozone; and
- Particulate matter (PM).

Where emission factors and activity data permit, ammonia (NH_3) estimates are also included as an important precursor to PM. Hazardous air pollutants are also delineated in the CAA, see *http://www.epa.gov/ttn/atw/188polls.html* for a complete list of regulated pollutants and their chemical abstract service [CAS] numbers.

The CAA requires the EPA to identify emission sources of these pollutants, quantify emissions, develop regulations for the identified source categories, and assess the public health and environmental impacts after the regulations are put into effect. The NEI is a tool that EPA can use to meet the CAA mandates. In this report, criteria and HAP emission estimates are discussed for CMV sources.

1.3 How is the EPA Going to Use This Version of the NEI?

It is anticipated that the emission inventory developed from this effort will have multiple end uses. The data have been formatted according to protocols established for the EPA's NEI submittals. The common data structure on which the NEI platform is based will allow the NEI emission data to be transferred to multiple end-users for a variety of purposes.

The criteria and HAP emission estimates developed for the NEI will be used to evaluate air pollution trends, air quality modeling analysis and impacts of potential regulations.

1.4 Report Organization

Following this introduction, Section 2.0 provides information on how the national CMV, emission estimates were developed. This inventory effort was coordinated by the EPA's Office of Transportation and Air Quality (OTAQ) and EIAG.

The appendix were created to provide technical details on how the national emissions were developed and how state and local inventory data (when provided) were incorporated into the national estimates. Appendix A provides a copy of the report documenting how the 2002 data were adjusted to reflect marine vessel activity and emissions for 2008.

2.0 DEVELOPMENT OF THE COMMERCIAL MARINE VESSEL COMPONENT FOR THE NEI

2.1 How Does This CMV Study Fit into the NEI?

The NEI was developed to include all point, nonpoint (sometimes referenced as "area"), and mobile sources. The approaches used in the point and nonpoint source categories are documented in other reports. Table 1 summarizes the approaches used to estimate emissions from all nonroad sources included in the NEI program. Those source categories and years that are included in this report are noted in bold.

The scope of this inventory component of the NEI was to compile criteria and HAP emissions data for CMVs operating in United States waters and federal waters extending 200 nautical miles from the United States' coastline. In this effort, national emission estimates were often developed and allocated to counties based on available Geographic Information System (GIS) data. The methodologies used to estimate emissions and the procedures used to spatially allocate them to the county-level are discussed in this report.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
NONROAD Categories			
Nonroad Gasoline, Diesel, LPG, CNG	2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's National Mobile Inventory Model (NMIM), which incorporates NONROAD2004. Where states provided alternate nonroad inputs, these data replaced EPA default inputs. State-supplied emissions data also replaced default EPA emission estimates.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
	1999	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) an updated 1999 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. Replaced State-submitted data for California for all NONROAD model categories; Pennsylvania for recreational marine and aircraft ground support equipment, and Texas for select equipment categories.
	1996, 1997, 1998, 2000 & 2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated year-specific national and California inventories, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios and California county-to-state ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. California results replace the diesel equipment emissions generated from prior application of county-to-national ratios.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1990 and 1996 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1990 and 1996. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1990 county-level emissions to estimate 1991-1995 emissions.
	1990	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1990 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1986, 1988, & 1989	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1985 and 1990 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1985 and 1990. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1985 county-level emissions to estimate 1986-1989 emissions.
	1987	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for 1987 by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1985	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1985 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1970, 1975, 1978, & 1980	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for all years by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.
	1996, 1997, 1998, 1999, 2000, & 2001	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD. NH_3 emissions for California were also recalculated using updated diesel fuel consumption values generated for California-specific runs, and assuming the 1996 county-level distribution.
	1985 & 1990	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD.
	1987	NH_3	Obtaining 1987 national fuel consumption estimates from Lockdown C NONROAD model and multiplying by NH_3 emission factors.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1970, 1975, 1978, & 1980	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1990, 1996, & 1999	HAPs	Speciation profiles applied to county VOC and PM estimates. Metal HAPs were calculated using fuel and activity-based emission factors. Some state data were provided and replaced national estimates. (2003)
Aircraft			
Commercial Aircraft	2008	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)
	2002	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) was run for criteria pollutants, VOC and PM emissions were speciated into HAP components. (2004)
	1990, 1996, 1999, 2000, 2001	VOC, NO_x, CO, SO_x	Input landing and take-off (LTO) data into FAA EDMS. National emissions were assigned to airports based on airport specific LTO data and BTS GIS data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2003)
General Aviation, Air Taxis	2008	Criteria and HAPs	Used FAA LTO data from TAF and OTAQ provided activity data for smaller airports derived from FAA 5010 master plans. EPA approved generic emission factors for criteria estimates. Speciation profiles were applied to VOC and PM estimates to get national HAP estimates. (2009)

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
General Aviation, Air Taxis (Continued)	1978, 1987, 1990, 1996, 1999, 2000, 2001, & 2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to develop national HAP estimates. (2004)
	1990, 1996, 1999, & 2002	Pb	Used Department of Energy (DOE) aviation gasoline usage data with lead concentration of aviation gasoline. (2004)
	1996	NH_3	Applied NH_3 emissions factors to 1996 national jet fuel and aviation gasoline consumption estimates.
Military Aircraft	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, 2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed. (2009)
	1970-1998	VOC, NO_x, CO, SO_X, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
Auxiliary Power Units	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)
	1985-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using LTO operations data from the FAA. Estimation methods prior to 1996 reported in EPA, 1998.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Unpaved Airstrips[1]	1985-2001	PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Aircraft Refueling[1]	1985-2001	VOC	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Commercial Marine Vessel (CMV)			
All CMV Categories	**2008**	**VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$**	**2002 estimates were adjusted by OTAQ to reflect 2008 activity levels., note that the SCCs for this category have changed such that the Diesel category refers to smaller vessels (Category 1 and 2) using distillate fuels and the Residual category refers to larger (Category 3) vessel using a blend of residual fuels (2009)**
	2008	**HAPs**	**OTAQ's 2008 estimates were speciated into HAP components using SEPA profiles**
	2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2001 Estimates carried over. Used state data when provided. (2004)
		HAPs	1999 Estimates carried over. Used state data when provided. (2004)
CMV Diesel	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Used criteria emission estimates in the background document for marine diesel regulations for 2000. Adjusted 2000 criteria emission estimates for other used based on fuel usage. Emissions were disaggregated into port traffic and underway activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
	1996	NH_3	Applied NH_3 emissions factors to 1996 distillate and residual fuel oil estimates (i.e., as reported in EIA, 1996).
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.
CMV Steam Powered	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Calculated criteria emissions based on EPA SIP guidance. Emissions were disaggregated into port traffic and under way activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, & 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
Military Marine	1997-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CMV Coal,[2] CMV, Steam powered, CMV Gasoline[2]	1997-1998	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CM Coal, CMV, Steam powered, CMV Gasoline, Military Marine	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Estimation methods reported in EPA, 1998.
Locomotives			
Class I, Class II, Commuter, Passenger, and Yard Locomotives	1978, 1987, 1990, 1996, 1999, 2000, 2000, & 2002	VOC, NO_x, CO, PM_{10}, $PM_{2.5}$	Criteria pollutants were estimated by using locomotive fuel use data from DOE EIA and available emission factors. County-level estimates were obtained by scaling the national estimates with the rail GIS data from DOT. State data replaced national estimates. (2004)

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Class I, Class II, Commuter, Passenger, and Yard Locomotives (Continued)	1978, 1987, 1990, 1996, 1999, 2000, 2001, & 2002	SO_2	SO_x emissions were calculated by using locomotive fuel use and fuel sulfur concentration data from EIA. County-level estimates were obtained by scaling the national estimates with the county level rail activity data from DOT. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. County-level estimates were obtained by scaling the national estimates with the county level rail activity from DOT. State data replaced national estimates. (2004)
	1997-1998	NH_3	Grew 1996 base year emissions using EGAS growth indicators.
	1996	NH_3	Applied NH_3 emissions factors to diesel consumption estimates for 1996.
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Notes:

* Dates included at the end of Estimation Method represent the year that the section was revised.

1 Emission estimates for unpaved airstrips and aircraft refueling are included in the area source NEI, since they represent non-engine emissions.

2 National Emission estimates for CMV Coal and CMV Gasoline were not developed though states and local agencies may have submitted estimates for these source categories.

EPA, 1998. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Factors and Inventory Group, National Air Pollutant Emission Trends, Procedures Document, 1900–1996, EPA-454/R-98-008. May 1998.

The target inventory area includes every state in the United States and every county within a state. There are no boundary limitations pertaining to traditional criteria pollutant nonattainment areas or to designated urban areas. The pollutants inventoried included all criteria pollutants (except for the other nonroad source category which addressed only HAPs in this report) and the 188 HAPs identified in Section 112(b) of the CAA. Some state or local agencies provided emissions information on more HAPs than those delineated in the CAA, only the federally regulated HAPs are included in the NEI.

In addition to numerous specific chemical compounds, the list of 188 HAPs includes several compound groups [e.g., individual metals and their compounds, polycyclic organic matter (POM)]; the NEI includes emission estimates for the individual compounds wherever possible. Many of the uses of the NEI depend upon data (e.g., toxicity) for individual compounds within these groups rather than aggregated data on each group as a whole.

The intent in presenting the following emission inventory approach is to provide sufficient and transparent documentation such that states and local agencies can use these approaches, in conjunction with their specific local activity data to develop more accurate and comparable emission estimates in future submittals.

2.2 What are Commercial Marine Vessels?

The CMV source category includes all boats and ships used either directly or indirectly in the conduct of commerce or military activity. These vessels range from 20-foot charter boats to large tankers which can exceed 1,000 feet in length (EPA, 1989). In spite of the broad range of vessels represented by this category, a number of common characteristics allow for the use of simple emission estimation methods. 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 it is assumed that Category 3 vessels primarily use residual blends while Category 1 and 2 vessels typically used distillate fuels.

The Category 3 (C3) inventory developed by OTAQ includes vessels which use C3 engines for propulsion. C3 engines are defined as having displacement above 30 liters per cylinder (U.S. EPA, 2003). 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. baseline, which is roughly equivalent to the border of the U.S. Exclusive Economic Zone (EEZ).

Category 1 and 2 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 Category 1 and 2 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 engines (EPA, 1989). Emissions from recreational marine vessels are included in the nonroad source category.

2.3 What Pollutants are Included in the National Emission Estimates for CMVs?

The EPA's Office of Transportation and Air Quality (OTAQ) provided estimates for all criteria pollutants including volatile organic compounds (VOC), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$) and carbon dioxide (CO_2). Criteria emissions were provided for Category 1 and 2 vessels (Carey, 2009b); Category 3 port, reduced speed zone, and cruising activities (Carey, 2009a and Carey, 2009c); and Category 3 interport activities (Carey, 2009d).

The VOC and PM estimates were speciated into hazardous air pollutants (HAP) components based on available data sources. The Swedish Environmental Protection Agency (SEPA) document *Methodology for Calculating Emissions from Ships: 1. Update of emission factors* served as the primary source of HAP emission factors which were converted into speciation profiles (Cooper and Gustafsson, 2004). Ammonia emission factors were also obtained from the SEPA, but as these factors require activity data, and such data were not available for Category 3 vessels operating in Federal waters, ammonia was estimated as a ratio of PM_{10} using the SEPA emission factors. Similar ratios were developed for Category 1 and 2 vessels, assuming that this fleet primarily operates on marine diesel fuel with 80.5 percent of the fleet equipped with medium speed engines and the remaining 19.5 percent were high speed engines. This provided a weighted NH_3 emission factor of 4.61E-03 g/kw-hr for operations at-sea and in-port. The PM_{10} factors vary for at-sea (0.2 g/kw-hr) and in-port (0.4 g/kw-hr), so our NH_3 / PM_{10} ratios were different for at-sea (2.31E-02) and in-port (1.15E-02).

While the SEPA document was used as the primary speciation source, other resources were investigated for potential inclusion in this effort. Recent BTEX data from Moldanova et al. were examined, but it included inconsistent benzene factors, some over 20% of hydrocarbon (HC) factors, were much higher than others found in recent publications and, as a result, were not included (Cook, 2009). CE-CERT metals data was also reviewed as it pertained to slow speed residual fuel engines (Cook, 2009). The CE-CERT emission factors were in line with the Swedish factors for nickel and lead, but they were an order of magnitude different for chromium, cadmium, and selenium. As a result, the Swedish factors were retained over the CE-CERT data based on the larger study sample size, while CE-CERT's manganese emission factors were added as these factors were not included in the Swedish study (Cook, 2009).

The complete pollutant list for CMVs is shown in Table 2-2.

2.4 How Were the CMV Emissions Estimated?

As noted above, the CMV criteria and CO_2 emission estimates were provided for this inventory by OTAQ. Category 3 commercial marine inventories were developed for a base year of 2002 then projected to 2008 applying regional adjustment factors to account for growth. In addition, NO_X adjustment factors were applied to account for implementation of the NO_X Tier 1 standard. Details about adjustments and growth factors can be found in the Category 3 documentation (Appendix A). For Category 1 and 2 marine diesel engines, the emission estimates were consistent with the 2008 Locomotive and Marine federal rule making (Carey, 2009b).

Table 2-2. Commercial Marine Vessel Pollutant List

2,2,4 Trimethylpentane	Carbon Monoxide*	Naphthalene
Acenaphthene	Chromium(VI)	Nickel
Acenaphthylene	Chromium (III)	Nitrogen Oxides*
Acetaldehyde	Chrysene	PAH, total
Acrolein	Cobalt	Phenanthrene
Ammonia	Dibenzo[a,h]Anthracene	Phosphorus
Anthracene	Dioxins/Furans	PM10 Primary*
Arsenic	Ethyl benzene	PM2.5 Primary+
Benz(a)anthracene	Fluoranthene	Polychlorinated Biphenyls
Benzene	Fluorene	Propionaldehyde
Benzo(a)pyrene	Formaldehyde	Pyrene
Benzo(b)fluoranthene	Hexachlorobenzene	Selenium
Benzo(g,h,i)perylene	Hexane	Styrene
Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene	Sulfur Dioxide*
Beryllium	Lead	Toluene
Cadmium	Manganese	VOCs*
Carbon Dioxide*	Mercury	Xylene

* Provided by OTAQ

\+ $PM_{2.5}$ was provided by OTAQ for all vessels and modes except for Category 3 Interport, where it was calculated using OTAQ guidance.

OTAQ's emissions were then allocated to individual GIS polygons using appropriate methods that varied by operating mode (i.e., hotelling, maneuvering, reduced speed zone, and underway). HAP emissions were estimated by applying speciation profiles to each polygon's VOC and PM estimates. Figure 2-1 provides an overview of the approach used to estimate and spatially allocate CMV emissions.

Speciation profiles were applied to the VOC, PM_{10}, and $PM_{2.5}$ emission estimates to calculate the associated HAP emissions using the following equation.

$$VOC\text{-}PM_{10/2.5} * \text{speciation profile}_i = \text{HAP emission estimate:}$$

Where:

HAP emission estimate	= HAP Emission estimate (tons/year) for pollutant:
$VOC\text{-}PM_{10/2.5}$	= VOC or PM emission estimate (tons/year)
Speciation $Profile_i$	= VOC or PM speciation fraction for HAP i

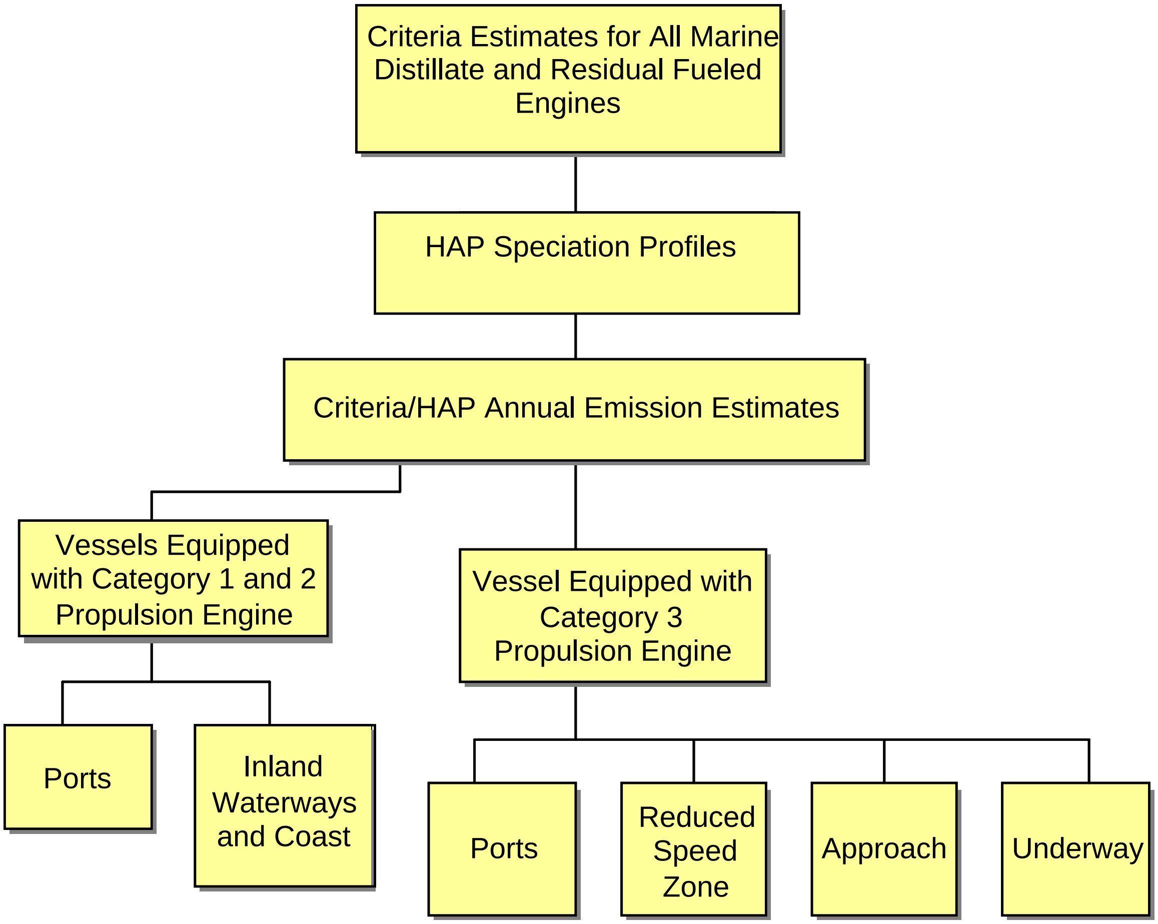

Figure 2-1. General Approach Used to Develop Marine Vessel Component of the 2008 National Emission Inventory

For Category I diesel-powered vessels, the speciation profiles were based on high-speed diesel vehicle (HSDV) factors obtained from information in the SEPA's *Methodology for Calculating Emissions from Ships: 1. Update of emission factors* (Cooper and Gustafsson, 2004). For Category 2 diesel-powered vessels, the speciation profiles were developed from medium-speed diesel vehicles (MSDV). Since emissions and activity data were provided as a combined value for all Category 1 and 2 vessels, the Category 1 and Category 2 emission factors were averaged to obtain a single emission factor for all diesel vessels. All port activities for Category 1 and 2 vessels were assumed to be maneuvering.

For Category 3 vessels, speciation profiles were developed using data from *Methodology for Calculating Emissions from Ships: 1. Update of emission factors* and assuming 80.5% of Category 3 vessels were equipped with slow-speed engines and 19.5% of vessels were equipped with medium speed engines based on vessel census data reported in the International Maritime Organization's (IMO) recent greenhouse gas (GHG) study (IMO 2009). Separate speciation profiles were created for Category 3 vessels for underway, maneuvering, and hotelling activities. Chromium emissions were split into hexavalent and trivalent chromium based on an assumption that 34% of total chromium was hexavalent and the remaining 66% was trivalent.

2.5 How Were Emissions Allocated?

Previous emissions allocations were based on waterway length and port county assignment. In this effort, spatial accuracy was greatly enhanced via the creation of GIS polygons representing port and waterway boundaries. GIS polygons allowed the estimation/allocation of emissions to defined port, waterway, and coastal areas, leading to improved spatial resolution compared to 2002's county-level emissions. Methodologies for both port and underway emissions are described in detail in the sections that follow.

2.6 How Were Port Emissions Allocated?

Port boundaries were developed using a variety of resources to identify the most accurate port boundaries. First, GIS data or maps provided directly from the port were used. Next, maps or port descriptions from local port authorities, port districts, etc. 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. Emphasis was placed on mapping the 117 ports with Category 3 vessel activity using available shape files of the port area. The Port of Huntington was developed differently given its large extent and limited available map data. The state of West Virginia provided a revised file of US Army Corps of Engineers *port terminals* reported to be part of the Port of Huntington-Tristate area. A 200 meter buffer of the water features near these port terminals was created to identify port area.

In all cases, polygons were created on land, bordering waterways and coastal areas, and were split by county boundary. Each polygon was identified by the port name and state and county FIPS in addition to a unique ShapeID. Smaller ports with Category 1 and 2 activities were mapped as small circles. Note that no Category 3 emissions were mapped to small circles. The final shapefile contained 159 ports and 196 polygons.

OTAQ provided Category 1 and 2 criteria emissions and activity as a single national number. These emissions and activity were allocated to ports based on total commodity tonnage data obtained from the U.S. Army Corps of Engineers (USACE) Principal Ports file for 2007 (U.S. ACE, 2009). Emissions were then assigned to polygons within a port based on port area.

OTAQ developed port-level emissions for 117 of the largest U.S. ports with Category 3 activity. Activity in megawatt hours (MWh) and resulting criteria and CO_2 emissions were provided by port for maneuvering and hotelling modes. Emissions were then assigned to polygons within a port based on port area. HAP emissions were then speciated from VOC and PM estimates for each polygon using the methodology described in Section 3.0.

2.7 How Were Underway Emissions Allocated?

For this inventory, a GIS polygon layer was created to more accurately represent the location of CMV-related activity and emissions. Inland waterway polygons were obtained from the Bureau of Transportation Statistics' National Transportation Atlas Database hydro polygon layer (U.S. DOT, 2007). These polygons were further divided by county boundary and waterway ID. Coastal waters were drawn using Mineral Management Service state-federal boundary files and were also divided to indicate county boundaries. Federal waters were included as large area blocks outlined by the Exclusive Economic Zone (EEZ) boundary provided by EPA, which extends to approximately 200 nautical miles from the coastline. The final product is a polygon layer that includes all inland and coastal state waters and federal waters along with FIP, polygon area, and a unique ShapeID. Underway emissions were allocated differently by vessel category and mode, as outlined below.

2.7.1 *Category 1 and 2 Underway*

OTAQ provided Category 1 and 2 criteria emissions and activity as a single national number. These emissions and activity were allocated to underway polygons in state waters based on total commodity movements (in tons) data obtained from USACE (U.S. ACE, 2001). These data were waterway-specific, so waterways that crossed into multiple FIPs had emissions assigned by waterway length in each polygon. HAP emissions were then speciated from VOC and PM estimates using the methodology described in Section 3.0 for each polygon.

2.7.2 *Category 3 Reduced Speed Zones (RSZ)*

OTAQ provided polyline shapefiles indicating location of RSZ activities along with port-specific RSZ emissions and activity. These polylines were intersected with existing shipping lane polygons, and emissions were allocated to polygons based on the approach segment length on a per-port basis. HAP emissions were then speciated from VOC and PM estimates using the methodology described in Section 3.0 for each polygon.

2.7.3 *Category 3 Approach*

OTAQ provided polyline shapefiles indicating location of cruising activities along with port-specific cruising emissions and activity. These polylines were intersected with our existing polygons, and emissions were allocated to polygons based on the approach segment length on a per-port basis. HAP emissions were then speciated from VOC and PM estimates using the methodology described in Section 3.0 for each polygon.

2.7.4 *Category 3 Interport*

OTAQ provided 4km grids for interport-only emissions for CO, CO_2, HC, NO_x, SO_x, and PM_{10}. These grids were provided in a customized projection which, without a custom geographic transformation, could not be converted to match the polygon layer's projection. Furthermore, the emission estimates provided by OTAQ were developed using EEZs which were in the GCS Arc Sphere projection. Per OTAQ's direction, the interport polygons were converted from North American Equidistant Conic to GCS Arc Sphere by using the data frame projections tool as the a transformation method. This approach was recommended by OTAQ in order to mirror previous methodology and provide emission estimates consistent with the recent Category 3 Commercial Marine Inventory. Zonal statistics tools were used to sum the gridded emissions within each underway polygon**.** HAP emissions were then speciated from VOC and PM estimates using the methodology described in Section 3.0 for each polygon.

2.8 QA/QC

Given the significant methodological changes over previous inventory efforts, several quality checks were implemented to ensure that these data were developed and allocated in a clear and reproducible manner. Some of the quality checks implemented include the following:

GIS shapefiles

- Topology was created and validated through several rounds or revisions to remove gaps or overlapping features both within and between polygon layers.
- Boundaries derived from Google Earth imagery were validated against Street Map network, port-provided map images, USACE ports points, and other online mapping resources to improve boundary accuracy.
- All final shapefiles and polygon characteristics (such as area, etc.) were managed and evaluated in a single projection to ensure quality area and distance measurements, consistent results across CMV activity types, and maximum accuracy across the study area. The only exception to this was in the case of the interport criteria emissions, as described in Section 4.2.4.

Emissions allocations and estimations

- Emission factors were compiled from a variety of sources, and emission factor development methodologies evaluated to identify the most accurate emission factor for use in this inventory effort.
- National emission sums were checked both before and after allocation to ensure no emissions were dropped or grown.
- HAP speciation profiles were checked for accuracy, and speciated emissions were checked on both the polygon and national level to ensure accuracy.
- All unit conversions were double-checked for errors.
- Emission sums were evaluated across activity types (i.e., hotelling, maneuvering, cruising, reduced speed zones, and interport) to ensure they consistently mirror activity levels.
- Port and underway emissions were examined across SCCs to ensure consistency with activity levels and vessel populations.

- 2008 pollutants and emissions were checked against the 2005 inventory to identify any missing pollutants or major changes compared to previous inventories. Discrepancies were investigated and revisions were made as needed.

2.9 What are the Results?

Table 2-3 summarizes the emission estimates for CMVs for criteria pollutants. Table 2-4 summarizes the emission estimates for individual HAPs. Note that for the purposes of this inventory vessels equipped with category 1 and 2 propulsion engines are assumed to operate on Distillate diesel, while vessels equipped with Category 3 propulsion engines are assumed to used a residual blend. Both tables provide data for all states; these 2008 estimates do not include state submitted data.

Table 2-3. Commercial Marine Vessel Criteria and Greenhouse Gas Emission Estimates 2008 (TPY)

Pollutant	Diesel Port	Diesel Underway	Diesel Total	Residual Port	Residual Underway	Residual Total	CMV Total
CO	113,452	37,817	151,269	5,871	68,588	74,459	**225,728**
CO_2	39,221,848	13,073,950	52,295,798	3,703,169	30,986,332	34,689,501	**86,985,299**
NH_3	210	140	350	64	323	387	**737**
NO_X	588,844	196,281	785,125	70,044	813,908	883,952	**1,669,077**
PM10-PRI	20,954	6,985	27,939	6,730	67,702	74,432	**102,371**
PM25-PRI	20,325	6,775	27,100	6,081	62,318	68,399	**95,499**
SO_2	34,803	11,601	46,404	52,512	522,327	574,839	**621,243**
VOC	12,752	4,251	17,003	2,412	28,711	31,123	**48,126**

* Note that for the purposes of this inventory vessels equipped with category 1 and 2 propulsion engines are assumed to operate on Distillate diesel, while vessels equipped with Category 3 propulsion engines are assumed to used a residual blend.

Table 2-4. Commercial Marine Vessel HAP Emission Estimates 2008 (TPY)

Pollutant	Diesel Port	Residual Port	Diesel Underway	Residual Underway
2,2,4-Trimethylpentane	3.825675	NA	1.062688	NA
Acenaphthene	0.36585	0.002068	0.101625	0.021188
Acenaphthylene	0.564019	0.003193	0.156672	0.032717
Acetaldehyde	710.6	0.552315	197.388896	6.574751
Acrolein	33.47466	NA	9.298516	NA
Anthracene	0.564019	0.003193	0.156672	0.032717
Arsenic	0.366686	2.358644	0.209535	11.836005
Benz[a]Anthracene	0.60975	0.003448	0.169375	0.035334
Benzene	194.5738	0.023636	54.048288	0.281365
Benzo[a]Pyrene	0.052384	0.011793	0.034923	0.059180
Benzo[b]Fluoranthene	0.104768	0.023586	0.069845	0.118360
Benzo[g,h,i,]Perylene	0.137194	0.000778	0.038109	0.007977
Benzo[k]Fluoranthene	0.052384	0.011793	0.034923	0.059180
Beryllium	NA	0.003674	NA	0.036965
Cadmium	0.059298	0.057506	0.035970	1.530064
Chromium (VI)	0.178105	1.224973	0.118737	4.419583
Chromium III	0.345733	2.377888	0.230489	8.579191
Chrysene	0.106706	0.000604	0.029641	0.006188
Cobalt	NA	1.717108	NA	10.426100
Dioxins/Furans as 2,3,7,8-TCDD TEQs	1.57E-06	1.18E-06	0.000001	0.000006
Ethyl Benzene	19.12838	NA	5.313438	NA
Fluoranthene	0.335363	0.001897	0.093156	0.019443
Fluorene	0.746944	0.004227	0.207484	0.043311
Formaldehyde	1430.802	3.786611	397.445137	45.075801
Hexachlorobenzene	0.000419	9.43E-05	0.000279	0.000473
Hexane	52.60303	NA	14.611954	NA
Indeno[1,2,3-c,d]Pyrene	0.104768	0.023586	0.069845	0.118360
Lead	1.571513	0.354705	1.047675	1.773791
Manganese	0.032059	0.385606	0.008905	3.879322
Mercury	0.000524	0.008218	0.000349	0.035508
Naphthalene	21.35649	0.121021	5.932360	1.240126
Nickel	10.47675	90.68502	6.984500	398.764466
PAH, total	26.5488	0.154501	7.496895	1.584859
Phenanthrene	0.85365	0.004829	0.237125	0.049480
Phosphorus		26.71489	NA	387.932155
Polychlorinated Biphenyls	0.005238	0.001179	0.003492	0.005918
Propionaldehyde	58.34154	NA	16.205985	NA
Pyrene	0.594506	0.003363	0.165141	0.034462
Selenium	0.000593	0.053465	0.000360	0.235603
Styrene	20.08479	NA	5.579110	NA
Toluene	30.6054	NA	8.501500	NA
Xylenes (Mixed Isomers)	45.9081	NA	12.752250	NA

* Note that for the purposes of this inventory vessels equipped with category 1 and 2 propulsion engines are assumed to operate on Distillate diesel, while vessels equipped with Category 3 propulsion engines are assumed to used a residual blend.

NA – Not Applicable.

2.10 Commercial Marine Vessel References

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Appendix A
2008 Category 3 Commercial Marine Vessel Inventory Methodology

Citation: U.S. Environmental Protection Agency. *Development of 2008CY Category 3 Commercial Marine Inventory*. Office of Transportation and Air Quality, Ann Arbor, MI. 2009.

Development of 2008CY Category 3 Commercial Marine Inventory

The Category 3 (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. baseline, which is roughly equivalent to the border of the U.S. Exclusive Economic Zone (EEZ). The U.S. region was clipped to the boundaries of the U.S. EEZ in areas where the 200nm boundary extended beyond the EEZ.

Category 3 commercial marine inventories were developed for a base year of 2002. [1] These were then projected to 2008. Regional adjustment factors were applied to account for growth. In addition, NO_X adjustment factors were applied to account for implementation of the NO_X Tier 1 standard. The methodology for each type of adjustment is described below.

Growth Factors by Geographic Region

The emissions inventory is calculated for nine geographic regions: Alaska East, Alaska West, East Coast, Gulf Coast, Hawaii East, Hawaii West, North Pacific, South Pacific, and the Great Lakes. Average annual growth rates from 2002-2020 were calculated for five regions: East Coast, Gulf Coast, North Pacific, South Pacific, and the Great Lakes. The Alaska regions were assigned the growth factor for the North Pacific region, while the Hawaii regions were assigned the growth factor for the South Pacific region. Each regional growth rate was then compounded over the inventory projection time period for 2008 (i.e., 6 years). The average annual growth rates and resulting multiplicative growth factors for each emission inventory region is presented in Table 1 below.

Table 1. Regional Emission Inventory Growth Factors for 2008

Emission Inventory Region	2002-2020 Average Annualized Growth Rate (%)	Multiplicative Growth Factor for 2008 Relative to 2002
Alaska East (AE)	3.3	1.2151
Alaska West (AW)	3.3	1.2151
East Coast (EC)	4.5	1.3023
Gulf Coast (GC)	2.9	1.1871
Hawaii East (HE)	5.0	1.3401
Hawaii West (HW)	5.0	1.3401
North Pacific (NP)	3.3	1.2151
South Pacific (SP)	5.0	1.3401
Great Lakes (GL)	1.7	1.1064

NO_X Adjustment Factors

The 2008 calendar year baseline inventory includes pre-control (Tier 0) engines and those subject to the NO_X Tier 1 standard that became effective in 2000. The NO_X emission factors (EFs) by tier and engine/ship type are given in Table 2.

Table 2. NO_X Emission Factors by Tier

Engine/Ship Type	NO_X EF (g/kW-hr)	
	Tier 0	Tier 1
Main		
Slow-Speed Diesel (SSD)	18.1	16.1
Medium-Speed Diesel (MSD)	14	12.5
Steam Turbine (ST)	2.1	n/a
Gas Turbine	6.1	n/a
Auxiliary		
Passenger Ship	14.6	13.0
Other Ships	14.5	12.9

The NO_X EFs by tier were then used with age distributions to generate calendar year NO_X EFs by engine/ship type for 2008. For 2002, Tier 0 EFs were used for simplicity. These calendar year NO_X EFs are provided in Table 3. Since the age distributions are different for vessels in the Great Lakes, NO_X EFs were determined separately for the Great Lakes.

Table 3. NO_X Emission Factors by Calendar Year

Engine/Ship Type	CY NO_X EF (g/kW-hr)		
	2002	2008	
		DSP[a]	GL[b]
Main			
Slow-Speed Diesel (SSD)	18.1	17.07	17.50
Medium-Speed Diesel (MSD)	14	13.01	13.74
Steam Turbine (ST)	2.1	2.1	2.1
Gas Turbine	6.1	6.1	n/a
Auxiliary			
Passenger Ship	14.6	13.76	14.32
Other Ships	14.5	13.60	14.16

[a]DSP = Deep sea ports and areas other than the Great Lakes
[b]GL = Great Lakes

Emission adjustment factors for NO_X were then calculated. Adjustment factors are ratios of the 2008 calendar year EFs to the 2002 calendar year EFs. The adjustment factors by engine/ship type are provided in Table 4.

Table 4. NO_X EF Adjustment Factors for 2008CY

Engine/Ship Type	2008 NO_X Adj (unitless)	
	DSP[a]	**GL[b]**
Main		
Slow-Speed Diesel (SSD)	0.9433	0.9670
Medium-Speed Diesel (MSD)	0.9293	0.9815
Steam Turbine (ST)	1.0000	1.0000
Gas Turbine	1.0000	n/a
Auxiliary		
Passenger Ship	0.9403	0.9784
Other Ships	0.9403	0.9784

Methodology for Development of 2008CY Port Inventories

For the non-California ports, 2002 emissions for each port are summed by engine/ship type. Propulsion and auxiliary emissions are summed separately, since the EF adjustment factors differ. The appropriate regional growth factor, as provided in Table 1, is then applied, along with the NO_X EF adjustment factors by engine/ship type in Table 4 to calculate the 2008 port inventories.

For the California ports, 2002 emissions for each port are summed by ship type. Propulsion and auxiliary emissions are summed separately, since the EF adjustment factors differ. The EF adjustment factors by engine/ship type in Table 4 are consolidated by ship type, using the CARB assumption that engines on all ships except passenger ships are 95 percent slow speed diesel (SSD) engines and 5 percent medium speed diesel engines (MSD) based upon a 2005 CARB survey. All passenger ships were assumed to be MSD engines. Steam turbines (ST) and gas turbines (GT) are not included in the CARB inventory. The NO_X EF adjustment factors by ship type are then applied, along with ship-specific growth factors used by CARB, to calculate the 2008 California port inventories. The ship-specific growth factors for 2008 relative to 2002 are provided in Table 5 below.

Table 5. Growth Factors by Ship Type for California Ports

Ship Type	Calendar Year	
	2002	2008
Auto	1.0000	1.1525
Bulk	1.0000	0.7412
Container	1.0000	1.4023
General	1.0000	0.9071
Passenger	1.0000	1.9823
Reefer	1.0000	1.0112
RoRo	1.0000	1.1525
Tanker	1.0000	1.3005

Methodology for Development of 2008CY Interport Inventories

The interport portion of the inventory is not segregated by engine or ship type. As a result, regional NO_X EF adjustment factors were developed based on the assumed mix of main (propulsion) engine types in each region. The mix of main engine types by region was developed using the ship call and power data and is presented in Table 6. Main engines are considered a good surrogate for interport emissions, since the majority of emissions while underway are due to the main engines. The NO_X EF adjustment factors by main engine type in Table 4 were used together with the mix of main engine types by region in Table 6 to develop the regional adjustment factors. The resulting NO_X EF regional adjustment factors are provided in Table 7. These NO_X EF regional adjustment factors, together with the regional growth factors in Table 1, were applied to calculate the 2008 interport inventories.

Table 6. Installed Power by Main Engine Type

Region	2008 Installed Power (%)			
	MSD	SSD	GT	ST
Alaska East (AE)	19.1%	18.4%	0.3%	62.2%
Alaska West (AW)	19.1%	18.4%	0.3%	62.2%
East Coast (EC)	25.6%	72.5%	0.9%	1.0%
Gulf Coast (GC)	13.7%	85.5%	0.0%	0.8%
Hawaii East (HE)	66.2%	18.5%	7.4%	8.0%
Hawaii West (HW)	66.2%	18.5%	7.4%	8.0%
North Pacific (NP)	5.1%	83.5%	1.6%	9.7%
South Pacific (SP)	17.8%	82.2%	0.0%	0.0%
Great Lakes (GL)	47.9%	43.7%	0.0%	8.4%

Table 7. NO_X EF Regional Adjustment Factors

Region	2002	2008
Alaska East (AE)	1.0000	0.9761
Alaska West (AW)	1.0000	0.9761
East Coast (EC)	1.0000	0.9408
Gulf Coast (GC)	1.0000	0.9419
Hawaii East (HE)	1.0000	0.9428
Hawaii West (HW)	1.0000	0.9428
North Pacific (NP)	1.0000	0.9490
South Pacific (SP)	1.0000	0.9408
Great Lakes (GL)	1.0000	0.9767

The resulting 2008 Category 3 emission inventories are shown in Table 8 for each of the nine geographic regions and the nation.

Table 8. 2008 Regional and National Emissions from Category 3 Vessel Main and Auxiliary Engines

Region	Metric Tonnes						
	NO_X	PM_{10}	$PM_{2.5}$ [a]	HC	CO	SO_2	CO_2
Alaska East (AE)	21,590	1,749	1,609	733	1,730	13,032	807,159
Alaska West (AW)	71,901	5,755	5,294	2,441	5,750	42,694	2,631,081
East Coast (EC)	271,707	23,021	21,180	9,573	22,665	190,767	10,696,360
Gulf Coast (GC)	195,240	16,839	15,492	6,903	16,990	125,728	7,604,870
Hawaii East (HE)	28,837	2,403	2,211	1,013	2,390	17,843	1,108,047
Hawaii West (HW)	40,573	3,381	3,110	1,426	3,362	25,105	1,559,016
North Pacific (NP)	30,248	2,647	2,435	1,153	2,568	18,790	1,216,723
South Pacific (SP)	132,669	10,982	10,103	4,692	11,368	81,896	5,145,632
Great Lakes (GL)	16,395	1,318	1,212	557	1,312	9,797	605,001
Total Metric Tonnes	**809,160**	**68,094**	**62,646**	**28,492**	**68,136**	**525,651**	**31,373,889**
Total Short Tons [b]	**891,946**	**75,061**	**69,056**	**31,407**	**75,107**	**579,431**	**34,583,792**

[a] Estimated from PM_{10} using a multiplicative adjustment factor of 0.92.

Reference (for 2002 inventory development)

1) U.S. Environmental Protection Agency, "Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Category 3 Marine Diesel Engines," Office of Transportation and Air Quality, EPA-420-D-09-002, June 2009.

Appendix B

2008 Commercial Marine Vessel Hazardous Air Pollutant Speciation Profiles

Table 1. Category 1 and 2 Hazardous Air Pollutant Speciation Profile for Port Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
540841	2,2,4-trimethylpentane	VOC	3.00E-04
83329	Acenaphthene	$PM_{2.5}$	1.80E-05
208968	Acenaphthylene	$PM_{2.5}$	2.78E-05
75070	Acetaldehyde	VOC	5.57E-02
107028	Acrolein	VOC	2.63E-03
NH3	Ammonia	PM_{10}	1.15E-02
120127	Anthracene	$PM_{2.5}$	2.78E-05
7440382	Arsenic	PM_{10}	1.75E-05
56553	Benz[a]Anthracene	$PM_{2.5}$	3.00E-05
71432	Benzene	VOC	1.53E-02
50328	Benzo[a]Pyrene	PM_{10}	2.50E-06
205992	Benzo[b]Fluoranthene	PM_{10}	5.00E-06
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	6.75E-06
207089	Benzo[k]Fluoranthene	PM_{10}	2.50E-06
7440439	Cadmium	PM_{10}	2.83E-06
16065831	Chromium III	PM_{10}	1.65E-05
18540299	Chromium VI	PM_{10}	8.50E-06
218019	Chrysene	$PM_{2.5}$	5.25E-06
600	Dioxin	PM_{10}	2.50E-09
100414	Ethylbenzene	VOC	1.50E-03
206440	Fluoranthene	$PM_{2.5}$	1.65E-05
86737	Fluorene	$PM_{2.5}$	3.68E-05
50000	Formaldehyde	VOC	1.12E-01
118741	Hexachlorobenzene	PM_{10}	2.00E-08
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	5.00E-06
439921	Lead	PM_{10}	7.50E-05
7439965	Manganese	PM_{10}	1.53E-06
7439976	Mercury	PM_{10}	2.50E-08
91203	Naphthalene	$PM_{2.5}$	1.05E-03
110543	n-Hexane	VOC	4.13E-03
7440020	Nickel	PM_{10}	5.00E-04
1336363	Polychlorinated Biphenyls	PM_{10}	2.50E-07
85018	Phenanthrene	$PM_{2.5}$	4.20E-05
123386	Propionaldehyde	VOC	4.58E-03
129000	Pyrene	$PM_{2.5}$	2.93E-05
7782492	Selenium	PM_{10}	2.83E-08
100425	Styrene	VOC	1.58E-03
108883	Toluene	VOC	2.40E-03

Table 2. Category 1 and 2 Hazardous Air Pollutant Speciation Profile for Underway Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
1330207	Xylene	VOC	3.60E-03
540841	2,2,4-trimethylpentane	VOC	2.50E-04
83329	Acenaphthene	$PM_{2.5}$	1.50E-05
208968	Acenaphthylene	$PM_{2.5}$	2.31E-05
75070	Acetaldehyde	VOC	4.64E-02
107028	Acrolein	VOC	2.19E-03
NH3	Ammonia	PM_{10}	2.31E-02
120127	Anthracene	$PM_{2.5}$	2.31E-05
7440382	Arsenic	PM_{10}	3.00E-05
56553	Benz[a]Anthracene	$PM_{2.5}$	2.50E-05
71432	Benzene	VOC	1.27E-02
50328	Benzo[a]Pyrene	PM_{10}	5.00E-06
205992	Benzo[b]Fluoranthene	PM_{10}	1.00E-05
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	5.63E-06
207089	Benzo[k]Fluoranthene	PM_{10}	5.00E-06
7440439	Cadmium	PM_{10}	5.15E-06
16065831	Chromium III	PM_{10}	3.30E-05
18540299	Chromium VI	PM_{10}	1.70E-05
218019	Chrysene	$PM_{2.5}$	4.38E-06
600	Dioxin	PM_{10}	5.00E-09
100414	Ethylbenzene	VOC	1.25E-03
206440	Fluoranthene	$PM_{2.5}$	1.38E-05
86737	Fluorene	$PM_{2.5}$	3.06E-05
50000	Formaldehyde	VOC	9.35E-02
118741	Hexachlorobenzene	PM_{10}	4.00E-08
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	1.00E-05
7439921	Lead	PM_{10}	1.50E-04
7439965	Manganese	PM_{10}	1.28E-06
7439976	Mercury	PM_{10}	5.00E-08
91203	Naphthalene	$PM_{2.5}$	8.76E-04
110543	n-Hexane	VOC	3.44E-03
7440020	Nickel	PM_{10}	1.00E-03
1336363	Polychlorinated Biphenyls	PM_{10}	5.00E-07

Table 2. Category 1 and 2 Hazardous Air Pollutant Speciation Profile for Underway Activities (Continued)

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
85018	Phenanthrene	$PM_{2.5}$	3.50E-05
123386	Propionaldehyde	VOC	3.81E-03
129000	Pyrene	$PM_{2.5}$	2.44E-05
7782492	Selenium	PM_{10}	5.15E-08
100425	Styrene	VOC	1.31E-03
108883	Toluene	VOC	2.00E-03
1330207	Xylene	VOC	3.00E-03

Table 3. Category 3 Hazardous Air Pollutant Speciation Profile for Hotelling Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
83329	Acenaphthene	$PM_{2.5}$	3.40E-07
208968	Acenaphthylene	$PM_{2.5}$	5.25E-07
75070	Acetaldehyde	VOC	2.29E-04
NH3	Ammonia	PM_{10}	1.08E-02
120127	Anthracene	$PM_{2.5}$	5.25E-07
7440382	Arsenic	PM_{10}	4.00E-04
56553	Benz[a]Anthracene	$PM_{2.5}$	5.67E-07
71432	Benzene	VOC	9.80E-06
50328	Benzo[a]Pyrene	PM_{10}	2.00E-06
205992	Benzo[b]Fluoranthene	PM_{10}	4.00E-06
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	1.28E-07
207089	Benzo[k]Fluoranthene	PM_{10}	2.00E-06
7440417	Beryllium	PM_{10}	5.46E-07
7440439	Cadmium	PM_{10}	5.90E-06
16065831	Chromium III	PM_{10}	3.96E-04
18540299	Chromium VI	PM_{10}	2.04E-04
218019	Chrysene	$PM_{2.5}$	9.93E-08
7440484	Cobalt	PM_{10}	2.92E-04
53703	Dibenzo[a,h]Anthracene	$PM_{2.5}$	0.00E+00
600	Dioxin	PM_{10}	2.00E-09

Table 3. Category 3 Hazardous Air Pollutant Speciation Profile for Hotelling Activities (Continued)

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
206440	Fluoranthene	$PM_{2.5}$	3.12E-07
86737	Fluorene	$PM_{2.5}$	6.95E-07
50000	Formaldehyde	VOC	1.57E-03
118741	Hexachlorobenzene	PM_{10}	1.60E-08
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	4.00E-06
7439921	Lead	PM_{10}	6.00E-05
7439965	Manganese	PM_{10}	5.73E-05
7439976	Mercury	PM_{10}	1.40E-06
91203	Naphthalene	$PM_{2.5}$	1.99E-05
7440020	Nickel	PM_{10}	1.54E-02
1336363	Polychlorinated Biphenyls	PM_{10}	2.00E-07
85018	Phenanthrene	$PM_{2.5}$	7.94E-07
7723140	Phosphorous	PM_{10}	4.38E-03
130498292	POM as 16-PAH	$PM_{2.5}$	2.49E-05
130498292	POM as 7-PAH	PM_{10}	4.50E-07
129000	Pyrene	$PM_{2.5}$	5.53E-07
7782492	Selenium	PM_{10}	9.08E-06

Table 4. Category 3 Hazardous Air Pollutant Speciation Profile for Maneuvering Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
83329	Acenaphthene	$PM_{2.5}$	3.40E-07
208968	Acenaphthylene	$PM_{2.5}$	5.25E-07
75070	Acetaldehyde	VOC	2.29E-04
NH3	Ammonia	PM_{10}	2.38E-03
120127	Anthracene	$PM_{2.5}$	5.25E-07
7440382	Arsenic	PM_{10}	8.74E-05
56553	Benz[a]Anthracene	$PM_{2.5}$	5.67E-07
71432	Benzene	VOC	9.80E-06
50328	Benzo[a]Pyrene	PM_{10}	4.37E-07
205992	Benzo[b]Fluoranthene	PM_{10}	8.74E-07

Table 4. Category 3 Hazardous Air Pollutant Speciation Profile for Maneuvering Activities (Continued)

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	1.28E-07
207089	Benzo[k]Fluoranthene	PM_{10}	4.37E-07
7440417	Beryllium	PM_{10}	5.46E-07
7440439	Cadmium	PM_{10}	2.26E-05
16065831	Chromium III	PM_{10}	1.27E-04
18540299	Chromium VI	PM_{10}	6.53E-05
218019	Chrysene	$PM_{2.5}$	9.93E-08
7440484	Cobalt	PM_{10}	5.94E-05
53703	Dibenzo[a,h]Anthracene	$PM_{2.5}$	0.00E+00
600	Dioxin	PM_{10}	4.37E-10
206440	Fluoranthene	$PM_{2.5}$	3.12E-07
86737	Fluorene	$PM_{2.5}$	6.95E-07
50000	Formaldehyde	VOC	1.57E-03
118741	Hexachlorobenzene	PM_{10}	3.50E-09
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	8.74E-07
7439921	Lead	PM_{10}	1.40E-05
7439965	Manganese	PM_{10}	5.73E-05
7439976	Mercury	PM_{10}	2.71E-07
91203	Naphthalene	$PM_{2.5}$	1.99E-05
7440020	Nickel	PM_{10}	3.25E-03
1336363	Polychlorinated Biphenyls	PM_{10}	4.37E-08
85018	Phenanthrene	$PM_{2.5}$	7.94E-07
7723140	Phosphorous	PM_{10}	1.79E-03
130498292	POM as 16-PAH	$PM_{2.5}$	2.49E-05
130498292	POM as 7-PAH	PM_{10}	4.90E-07
129000	Pyrene	$PM_{2.5}$	5.53E-07
7782492	Selenium	PM_{10}	1.91E-06

Table 5. Category 3 Hazardous Air Pollutant Speciation Profile for Underway Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
83329	Acenaphthene	$PM_{2.5}$	3.40E-07
208968	Acenaphthylene	$PM_{2.5}$	5.25E-07

Table 5. Category 3 Hazardous Air Pollutant Speciation Profile for Underway Activities (Continued)

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
75070	Acetaldehyde	VOC	2.29E-04
NH3	Ammonia	PM_{10}	4.77E-03
120127	Anthracene	$PM_{2.5}$	5.25E-07
7440382	Arsenic	PM_{10}	1.75E-04
56553	Benz[a]Anthracene	$PM_{2.5}$	5.67E-07
71432	Benzene	VOC	9.80E-06
50328	Benzo[a]Pyrene	PM_{10}	8.74E-07
205992	Benzo[b]Fluoranthene	PM_{10}	1.75E-06
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	1.28E-07
207089	Benzo[k]Fluoranthene	PM_{10}	8.74E-07
7440417	Beryllium	PM_{10}	5.46E-07
7440439	Cadmium	PM_{10}	2.26E-05
7440473	Chromium	PM_{10}	1.92E-04
16065831	Chromium III	PM_{10}	1.27E-04
18540299	Chromium VI	PM_{10}	6.53E-05
218019	Chrysene	$PM_{2.5}$	9.93E-08
7440484	Cobalt	PM_{10}	1.54E-04
53703	Dibenzo[a,h]Anthracene	$PM_{2.5}$	0.00E+00
600	Dioxin	PM_{10}	8.74E-10
206440	Fluoranthene	$PM_{2.5}$	3.12E-07
86737	Fluorene	$PM_{2.5}$	6.95E-07
50000	Formaldehyde	VOC	1.57E-03
118741	Hexachlorobenzene	PM_{10}	6.99E-09
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	1.75E-06
7439921	Lead	PM_{10}	2.62E-05
7439965	Manganese	PM_{10}	5.73E-05
7439976	Mercury	PM_{10}	5.24E-07
91203	Naphthalene	$PM_{2.5}$	1.99E-05
7440020	Nickel	PM_{10}	5.89E-03
1336363	Polychlorinated Biphenyls	PM_{10}	8.74E-08
85018	Phenanthrene	$PM_{2.5}$	7.94E-07
7723140	Phosphorus	PM_{10}	5.73E-03
130498292	POM as 16-PAH	$PM_{2.5}$	2.49E-05
130498292	POM as 7-PAH	PM_{10}	4.90E-07
129000	Pyrene	$PM_{2.5}$	5.53E-07
7782492	Selenium	PM_{10}	3.48E-06

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1.0 INTRODUCTION

1.1 What are Locomotive Sources?

The locomotive source category 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 does not include locomotives powered by electricity or steam. Emissions associated with the operation of electric locomotives would be included in the point source utility emission estimate. It is believed that the number of wood or coal driven steam locomotives is currently very small; therefore, these types of locomotives are not included in this inventory.

The locomotive source category is further divided up into three categories: Class I line haul, Class II/III line haul, and Class I yard. The national rail estimates were developed by the Eastern Regional Technical Advisory Committee hereafter referenced as ERTAC Rail. This group is comprised of eastern states' regulatory agencies in collaboration with the rail industry. ERTAC Rail developed emissions estimates based on fuel data obtained from the American Association of Railroads for each subcategory. California locomotive emission estimates were handled separately from the rest of the United States because of their use of low sulfur locomotive diesel fuels.

2.0 DEVELOPMENT OF THE LOCOMOTIVE COMPONENT FOR THE NEI

2.1 What Pollutants are Included in the National Emission Estimates for Locomotives?

All of the criteria pollutants, VOC, CO, NO_x, SO_x, PM, and $PM_{2.5}$, are included in the locomotive component of the NEI. OTAQ identified the HAPs for which data were available to develop inventory estimates (Scarbro, 2001). The hazardous air pollutants (HAPs), listed below, were identified based on available test data and accepted emission estimation procedures. Emission estimation methods have changed over the history of the NEI, as outlined briefly in Table 2-2 for nonroad sources.

Table 2-1. Locomotive Pollutant List

1,3-Butadiene	Beryllium	Napthalene
2,2,4-Trimethylpentane	Cadmium	n-Hexane
Acenaphthene	Chromium (Hexavalent)	Nickel
Acenaphthylene	Chromium (Trivalent)	Phenanthrene
Acetaldehyde	Chrysene	PAH Propionaldehyde
Acrolein	Dibenz(a,h) anthracene	Pyrene
Anthracene	Ethyl Benzene	Styrene
Arsenic	Fluoranthene	Toluene
Benzene	Fluorene	Xylene
Benzo(a)anthracene	Formaldehyde	
Benzo[a]pyrene	Indeno(1,2,3-cd) pyrene	
Benzo[b]fluoranthene	Lead	
Benzo[g,h,i,]perylene	Manganese	
Benzo[k]fluoranthene	Mercury	

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
NONROAD Categories			
Nonroad Gasoline, Diesel, LPG, CNG	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's National Mobile Inventory Model (NMIM), which incorporates NONROAD2008. Where states provided alternate NMIM nonroad inputs, these data replaced EPA default inputs.
	2005	VOC, NO_x, CO, SO_2, , PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's NMIM, which incorporates NONROAD2005. Where States provided alternate nonroad inputs, these data replaced EPA default inputs.
	2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's NMIM, which incorporates NONROAD2004. Where states provided alternate nonroad inputs, these data replaced EPA default inputs. State-supplied emissions data also replaced default EPA emission estimates.
	1999	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) an updated 1999 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. Replaced State-submitted data for California for all NONROAD model categories; Pennsylvania for recreational marine and aircraft ground support equipment, and Texas for select equipment categories.
	1996, 1997, 1998, 2000 & 2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated year-specific national and California inventories, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios and California county-to-state ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. California results replace the diesel equipment emissions generated from prior application of county-to-national ratios.

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1990 and 1996 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1990 and 1996. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1990 county-level emissions to estimate 1991-1995 emissions.
	1990	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1990 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1986, 1988, & 1989	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1985 and 1990 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1985 and 1990. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1985 county-level emissions to estimate 1986-1989 emissions.
	1987	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for 1987 by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.
	1985	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1985 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1970, 1975, 1978, & 1980	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for all years by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1996, 1997, 1998, 1999, 2000, & 2001	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD. NH_3 emissions for California were also recalculated using updated diesel fuel consumption values generated for California-specific runs, and assuming the 1996 county-level distribution.
	1985 & 1990	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD.
	1987	NH_3	Obtaining 1987 national fuel consumption estimates from Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1970, 1975, 1978, & 1980	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1990, 1996, & 1999	HAPs	Speciation profiles applied to county VOC and PM estimates. Metal HAPs were calculated using fuel and activity-based emission factors. Some state data were provided and replaced national estimates. (2003)
Aircraft			
Commercial Aircraft	2008	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)
	2002 and 2005	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) was run for criteria pollutants, VOC and PM emissions were speciated into HAP components. (2004)
	1990, 1996, 1999, 2000, 2001	VOC, NO_x, CO, SO_x	Input landing and take-off (LTO) data into FAA EDMS. National emissions were assigned to airports based on airport specific LTO data and BTS GIS data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2003)
General Aviation, Air Taxis	2008	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO for aircraft identified as Air taxis. (2010) Used FAA LTO data from TAF and OTAQ provided activity data for smaller airports derived from FAA 5010 master plans. EPA approved generic emission factors for criteria estimates. Speciation profiles were applied to VOC and PM estimates to get national HAP estimates. (2010)

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
General Aviation, Air Taxis (Continued)	2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2002 emissions for approximately 4,000 largest airports were calculated via EDMS and SIP guidance and included in the 2005 NEI as point sources. Only airports in FAA's T100 and TAF databases were included. State point source submittals were incorporated.
	1978, 1987, 1990, 1996, 1999, 2000, 2001, & 2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to develop national HAP estimates. (2004)
	1990, 1996, 1999, & 2002	Pb	Used Department of Energy (DOE) aviation gasoline usage data with lead concentration of aviation gasoline. (2004)
	1996	NH_3	Applied NH_3 emissions factors to 1996 national jet fuel and aviation gasoline consumption estimates.
Military Aircraft	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed. (2010)
	2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2002 emissions were included in the 2005 NEI as point sources similar to other TAF reported data.
	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, 2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed.
	1970-1998	VOC, NO_x, CO, SO_X, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
Auxiliary Power Units and Ground Support Equipment	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)
	2002 and 2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, HAPs	Computed via NONROAD2005 model runs
	1985-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using LTO operations data from the FAA. Estimation methods prior to 1996 reported in EPA, 1998.

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Unpaved Airstrips[1]	1985-2001	PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Aircraft Refueling[1]	1985-2001	VOC	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Commercial Marine Vessel (CMV)			
All CMV Categories	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	OTAQ provided CAP emission estimates for all CMV categories. Note that the SCCs for this category have changed such that the Diesel category refers to smaller vessels (Category 1 and 2) using distillate fuels and the Residual category refers to larger (Category 3) vessels using a blend of residual fuels. Emissions were allocated to segments using GIS shapefiles and adjusted based on limited state data (2010)
	2008	HAPs	OTAQ's 2008 estimates were speciated into HAP components using SEPA profiles (2009)
CMV Diesel	2002 and 2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2001 Estimates carried over. Used state data when provided. (2004)
		HAPs	1999 Estimates carried over. Used state data when provided. (2004)
	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Used criteria emission estimates in the background document for marine diesel regulations for 2000. Adjusted 2000 criteria emission estimates for other used based on fuel usage. Emissions were disaggregated into port traffic and underway activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
	1996	NH_3	Applied NH_3 emissions factors to 1996 distillate and residual fuel oil estimates (i.e., as reported in EIA, 1996).
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
CMV Steam Powered	2005	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$, HAPs	2002 estimates grown to 2005 (2008).
	2002	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$, HAPs	2002 based estimates were developed for port and underway category 3 (C3) vessels as part of a rulemaking effort. Emissions were developed separately for near port and underway emissions. For near port emissions, inventories for 2002 were developed for 89 deep water and 28 Great Lake ports in the U.S. The Waterway Network Ship Traffic, Energy, and Environmental Model (STEEM) was used to provide emissions from ships traveling in shipping lanes between and near individual ports (2008)
	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Calculated criteria emissions based on EPA SIP guidance. Emissions were disaggregated into port traffic and under way activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, & 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
Military Marine	1997-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CMV Coal,[2] CMV, Steam powered, CMV Gasoline[2]	1997-1998	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CM Coal, CMV, Steam powered, CMV Gasoline, Military Marine	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Estimation methods reported in EPA, 1998.
Locomotives			
Class I, II, III and Yard operations	**2008**	**VOC, NO_x, CO, PM_{10}, $PM_{2.5}$, SO_x & HAPs**	**Criteria emission estimates were provided to EPA by ERTAC. These data were assigned to individual railway segments using DOT shapefiles and guidance from ERTAC. HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. (2010)**

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Class I, Class II, Commuter, Passenger, and Yard Locomotives	1978, 1987, 1990, 1996, 1999, 2000, 2000, 2002, & 2005	VOC, NO_x, CO, PM_{10}, $PM_{2.5}$	Criteria pollutants were estimated by using locomotive fuel use data from DOE EIA and available emission factors. County-level estimates were obtained by scaling the national estimates with the rail GIS data from DOT. State data replaced national estimates. (2004)
	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, & 2005	SO_2	SO_x emissions were calculated by using locomotive fuel use and fuel sulfur concentration data from EIA. County-level estimates were obtained by scaling the national estimates with the county level rail activity data from DOT. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. County-level estimates were obtained by scaling the national estimates with the county level rail activity from DOT. State data replaced national estimates. (2004)
	1997-1998	NH_3	Grew 1996 base year emissions using EGAS growth indicators.
	1996	NH_3	Applied NH_3 emissions factors to diesel consumption estimates for 1996.
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Notes:

* Dates included at the end of Estimation Method represent the year that the section was revised.

1 Emission estimates for unpaved airstrips and aircraft refueling are included in the area source NEI, since they represent non-engine emissions.

2 National Emission estimates for CMV Coal and CMV Gasoline were not developed though states and local agencies may have submitted estimates for these source categories.

EPA, 1998. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Factors and Inventory Group, National Air Pollutant Emission Trends, Procedures Document, 1900–1996, EPA-454/R-98-008. May 1998.

3.0 HOW WERE LOCOMOTIVE EMISSIONS ESTIMATED?

ERTAC Rail used confidential railroad-provided data to generate railroad-specific criteria emission estimates for line haul and rail yards at the rail segment and rail yard level, respectively. Appendices A-C provide more detail on how emissions were developed and includes critical data used in calculating these estimates. This section of the report describes the emission estimating methods used in general terms as well as the approach for reallocating the emissions to protect confidential data. The data and documentation provided with respect to ERTAC Rail's emission estimates pertain to the version that was incorporated into the NEI and does not reflect recent revisions.

3.1 Line Haul Criteria Emissions Estimates

Criteria pollutant emissions were estimated by applying emission factors to the total amount of distillate fuel oil used by line haul locomotives. Fuel usage was obtained from publically available Class I Railroad Annual Reports (Form R-1). The R-1 reports are submitted to the Surface Transportation Board annually and include financial and operations data to be used in monitoring rail industry health and identifying changes that may affect national transportation policy. Additionally, each railroad provided fleet mix information that allowed ERTAC Rail to calculate railroad-specific emission factors. Weighted Emission Factors (EF) per pollutant for each gallon of fuel used (gm/gal or lbs/gal) were calculated for each Class I railroad fleet based on its fraction of line haul locomotives at each regulated Tier level. EPA emission factors were used for $PM_{2.5}$, SO_2, and NH_3.

The weighted emission factors were then applied to the link-specific fuel consumption to obtain emissions for each rail segment. Given the confidentiality of the activity data, emissions for criteria pollutants were provided to EPA by ERTAC Rail by county for Class I line haul. Class II/III rail was provided by railroad company and county. Appendices A and B provide more detail on the Class I and Class II/III line haul emission development, respectively.

3.2 Rail Yard Criteria Emissions Estimates

Rail yard locations were identified using a database from the Federal Railroad Administration. Criteria pollutant emissions were estimated by applying emission factors to the total amount of distillate fuel used by locomotives. Each railroad provided fleet mix information that allowed ERTAC to calculate railroad-specific emission factors. The company-specific, system wide fleet mix was used to calculate weighted average emissions factors for switchers operated by each Class I railroad. EPA emission factors were used for $PM_{2.5}$, SO_2, and NH_3.

R-1 report-derived fuel use was allocated to rail yards using an approximation of line haul activity data within the yard; see Appendix C for more details. These fuel consumption values were further revised by direct input from the Class I railroads. The weighted emission factors were then applied to the yard-specific fuel consumption to obtain emissions for each yard. Since the rail yard inventory was based on publically-available data, the final criteria emission estimates were provided per rail yard.

3.3 Hazardous Air Pollutant Emissions Estimates

HAP emissions were estimated by applying speciation profiles to the VOC or PM estimates. The speciation profiles were derived from *Evaluation of Factors that Affect Diesel Exhaust Toxicity* (Truex and Norbeck, 1998), and data provided by OTAQ (Scarbro, 2001 and 2002). It should be noted that since California uses low sulfur diesel fuel and emission factors specific for California railroad fuels were available, calculations of the state's emissions were done separately from the other states. The HAP speciation profile used in this effort is shown in Table 3-1. HAP estimates were calculated at the yard and link level, after the criteria emissions had been allocated.

Table 3-1. Hazardous Air Pollutant Speciation Profile for 2008 Locomotive Emission Estimation

Pollutant Name	California	All Other States	Speciation Base
1,3 Butadiene	0.0000615	0.0047735	PM_{10}
2-2-4 Trimethylpentane	0.0022425	0.0022425	VOC
Acenaphthene	0.0000080	0.0000306	PM_{10}
Acenaphthylene	0.0002182	0.0004275	PM_{10}
Acetaldehyde	0.0004492	0.0276274	PM_{10}
Acrolein	0.0000855	0.0045943	PM_{10}
Anthracene	0.0000535	0.0001009	PM_{10}
Arsenic	0.0000004	0.0000004	PM_{10}
Benzene	0.0000517	0.0038020	PM_{10}
Benzo(a)anthracene	0.0000121	0.0000160	PM_{10}
Benzo(a)pyrene	0.0000044	0.0000027	PM_{10}
Benzo(b)fluoranthene	0.0000044	0.0000064	PM_{10}
Benzo(ghi)perylene	0.0000044	0.0000031	PM_{10}
Benzo(k)fluoranthene	0.0000044	0.0000052	PM_{10}
Beryllium	0.0000280	0.0000280	PM_{10}
Cadium	0.0000280	0.0000280	PM_{10}
Chromium (III)	0.0000001	0.0000040	PM_{10}
Chromium (VI)	0.0000000	0.0000021	PM_{10}
Chrysene	0.0000092	0.0000119	PM_{10}
Dibenz(a,h)anthracene	0.0000000	0.0000000	PM_{10}
Ethylbenzene	0.0020000	0.0020000	VOC
Fluoranthene	0.0000601	0.0000746	PM_{10}
Fluorene	0.0000619	0.0001407	PM_{10}
Formaldehyde	0.0009451	0.0636582	PM_{10}
Indeno(1,2,3-cd)pyrene	0.0000033	0.0000027	PM_{10}
Lead	0.0000840	0.0000840	PM_{10}
Manganese	0.0000020	0.0000020	PM_{10}
Mercury	0.0000280	0.0000280	PM_{10}
Napthalene	0.0018505	0.0025756	PM_{10}
n-Hexane	0.0055000	0.0055000	VOC

Table 3-1. Hazardous Air Pollutant Speciation Profile for 2008 Locomotive Emission Estimation (Cont.)

Pollutant Name	California	All Other States	Speciation Base
Nickel	0.0000066	0.0000066	PM_{10}
Phenanthrene	0.0002822	0.0005671	PM_{10}
Propionaldehyde	0.0061000	0.0061000	VOC
Pyrene	0.0000771	0.0001054	PM_{10}
Styrene	0.0021000	0.0021000	VOC
Toluene	0.0032000	0.0032000	VOC
Xylene	0.0048000	0.0048000	VOC

4.0 HOW WERE COUNTY LINE HAUL EMISSIONS REALLOCATED TO INDIVIDUAL RAIL SEGMENTS?

4.1 Class I Line Haul Emissions Allocation

Class I line haul emissions were allocated to rail segments based on segment-specific railroad traffic data (ton miles) obtained from the Department of Transportation (BTS, 2009). This dataset categorizes the segments' level of activity into ranges of MGTM and is populated by FRA. Emissions were divided between all mainline segments using these activity ranges as a proxy to allocate more emissions to segments with higher activity.

Since the activity data were provided as ranges, a single "allocation value", typically the midpoint of the range, was selected for use in the emissions allocation. The exception to this was the "0" activity category, which by definition had "unknown" activity. As a result, most mainline segments with the "0" activity category were not included in the emissions calculation/allocation. However, there was a small subset of segments that did have known activity values in the confidential data set but were labeled as "unknown" in the publically available data set. Those segment IDs were provided by ERTAC Rail for inclusion in the emission allocation; however, the activity of these segments was averaged to protect confidential data. Table 4-1 lists the activity categories along with their ranges in MGTM/mi and the allocation value used in the emissions spatial allocation.

Table 4-1. Line Haul Segment Activity (MGTM/Mi) Categories

Category	Range Minimum	Range Maximum	Allocation Value Used
0*	0.0003	0.09	0.01233
1	0.1	4.9	2.5
2	5	9.9	7.45
3	10	19.9	14.95
4	20	39.9	29.95
5	40	59.9	49.95
6	60	99.9	79.95
7	100	1000000	100

* The "0" category has "unknown" activity in the publically available segment data. As a result, this table lists the minimum, maximum, and average of the confidential activity data greater than zero that were categorized as "unknown" in the public data.

The county emission sums were reallocated to the segments by multiplying the county emissions by the segment's allocation value divided by the sum of the allocation values for all links within the county.

$$E_{iL} = E_{iC} * \frac{A_L}{\sum_{C=1}^{N} A_{LC}}$$

Where:

E_{iL} = Emissions of pollutant i per link L (tons/year).
E_{iC} = Emissions of pollutant i per county C (tons/year).
A_L = Allocation value for link L per activity category from public BTS dataset
A_{LC}= Sum of allocation values for all links in county C from public BTS dataset

Note that rail line data for Puerto Rico, U.S. Virgin Islands, and Hawaii data were not included in ERTAC Rail's shapefile and were developed separately; however, since these areas have exclusively Class II/III railroads present, these efforts are discussed in the following section.

4.2 Class II/III Line Haul Emissions Allocation

ERTAC Rail created a shapefile of Class II/III mainline rail segments from their FRA-provided proprietary shapefile as described in Appendix B for the contiguous 48 states and Alaska. Raw rail line data for Puerto Rico were obtained from USGS (Scanlon and Briere, 2000), and rail line data for Hawaii was obtained from ESRI's Digital Chart of the World (ESRI 2010). The U.S. Virgin Islands have no rail lines. Because Class II/III railroads are less likely to use rail segments that are heavily traveled by Class I railroads, the activity-based approach used for Class I lines was not appropriate. Instead, Class II/III line haul emissions were allocated to rail segments using segment length as a proxy.

The county emission sums were reallocated to the segments by multiplying the county emissions by the segment's length divided by the sum of the length for all links within the county.

$$E_{iL} = E_{iC} * \frac{l_L}{\sum_{C=1}^{N} l_{LC}}$$

Where:

E_{iL} = Emissions of pollutant i per link L (tons/year).
E_{iC} = Emissions of pollutant i per county C (tons/year).
l_L = Allocation value for link L per activity category from public BTS dataset
l_{LC} = Sum of allocation values for all links in county C from public BTS dataset

Since ERTAC Rail used proprietary data to develop the shapefile, some segment IDs were not found in the EIS data set. These segments were manually identified, and their emissions were allocated to the nearest segment within the EIS data set.

4.3 Rail Yard Emissions Allocation

Rail yard emissions were developed based on yard name and ownership properties. As a result, unique yards needed to be identified and emissions summed. Unfortunately, the yard data lacked detail necessary for confident duplicate checks and yard matching such as address, detailed yard name, etc. As a result, a GIS was used to find the centroid of the yards based on the latest public BTS rail network, using the yard name and FIPS. The list of unique yards was further examined against ERTAC's data and within Google Earth to identify any yards that required further revision. A crosswalk of original ERTAC data to new, consolidated yard IDs facilitated the summing of activity and emissions. 753 unique yards were identified nationwide. This underestimate of the total number of yards is most likely due to using line-haul-focused data to identify locations and develop rail yard emissions.

Once the unique yards were identified and criteria emissions were summed at the yard, the PM and VOC-based HAP speciation profile was applied to estimate HAP emissions at each yard.

4.4 State Provided Data

In this version of NEI, state and local agencies were invited to provide locomotive data that replaced the estimates based on national fuel consumption. However, only a small rail yard dataset was received from Kentucky. Their rail yard list was compared with the ERTAC/ERG yard list, and 2 yards were found in both sets. These yards were merged so as to avoid duplication in activity or emissions.

4.5 What are the Results?

Table 3 summarizes the 2008 locomotive mobile source emission estimates.

Table 3. 2008 Locomotive Emissions Data

2008 Locomotive Criteria Emissions				
Pollutant Name	**Class I Line Haul**	**Class II/III Line Haul**	**Rail Yard**	**TOTAL**
CO	110,969	5,055	9,152	125,176
NH_3	347	16	27	390
NO_X	754,433	51,342	73,741	879,516
PM_{10}-PRI	25,477	1,264	2,086	28,827
PM_{25}-PRI	23,439	1,163	2,024	26,626
SO_2	7,836	357	619	8,811
VOC	37,941	1,896	4,824	44,661
2008 Locomotive Hazardous Air Pollutant Emissions				
Pollutant Name	**Class I Line Haul**	**Class II/III Line Haul**	**Rail Yard**	**TOTAL**
1,3 Butadiene	116.7941	5.7969	9.3296	131.9206
2-2-4 Trimethylpentane	85.0832	4.2511	10.8178	100.1521
Acenaphthene	0.7569	0.0376	0.0609	0.8554

Table 3. 2008 Locomotive Emissions Data (Cont.)

2008 Locomotive Hazardous Air Pollutant Emissions				
Pollutant Name	**Class I Line Haul**	**Class II/III Line Haul**	**Rail Yard**	**TOTAL**
Acenaphthylene	10.6772	0.5298	0.8639	12.0709
Acetaldehyde	676.0572	33.5552	54.0089	763.6213
Acrolein	112.4351	5.5806	8.9828	126.9985
Anthracene	2.5231	0.1252	0.2042	2.8525
Arsenic	0.0091	0.0005	0.0007	0.0103
Benzene	93.0272	4.6173	7.4312	105.0757
Benzo(a)anthracene	0.4047	0.0201	0.0329	0.4577
Benzo(a)pyrene	0.0717	0.0036	0.0059	0.0812
Benzo(b)fluoranthene	0.1607	0.0079	0.0131	0.1817
Benzo(ghi)perylene	0.0798	0.0040	0.0066	0.0904
Benzo(k)fluoranthene	0.1312	0.0065	0.0107	0.1484
Beryllium	0.7138	0.0354	0.0584	0.8076
Cadium	0.7138	0.0354	0.0584	0.8076
Chromium (III)	0.0985	0.0049	0.0079	0.1113
Chromium (VI)	0.0508	0.0025	0.0041	0.0574
Chrysene	0.2998	0.0149	0.0244	0.3391
Ethylbenzene	75.8814	3.7914	9.6479	89.3207
Fluoranthene	1.8868	0.0936	0.1538	2.1342
Fluorene	3.5039	0.1739	0.2830	3.9608
Formaldehyde	1,557.66	77.3124	124.4335	1759.4059
Indeno(1,2,3-cd)pyrene	0.0684	0.0034	0.0056	0.0774
Lead	2.1413	0.1062	0.1753	2.4228
Manganese	0.0520	0.0026	0.0043	0.0589
Mercury	0.7138	0.0354	0.0584	0.8076
Napthalene	64.8766	3.2187	5.2765	73.3718
n-Hexane	208.6739	10.4263	26.5317	245.6319
Nickel	0.1669	0.00983	0.0137	0.19043
Phenanthrene	14.1555	0.7024	1.1450	16.0029
Propionaldehyde	231.4383	11.5637	29.4261	272.4281
Pyrene	2.6566	0.1318	0.2161	3.0045
Styrene	79.6755	3.9809	10.1303	93.7867
Toluene	121.4103	6.0662	15.4366	142.9131
Xylene	182.1154	9.0993	23.1549	214.3696

5.0 REFERENCES

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Appendix A

ERTAC Class I Line Haul Documentation

DRAFT

ERTAC Rail Emissions Inventory
Part 1: Class I Line-Haul Locomotives

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Acknowledgments:
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Raquel Wright, Federal Railroad Administration
Julie McDill, Mid-Atlantic Regional Air Management Association
Patrick Davis, Mid-Atlantic Regional Air Management Association
Laurel Driver, US EPA, Office of Air Quality Planning and Support
Byeong Kim, GA Environmental Protection Division

Introduction

Air protection agencies from twenty-seven states, coordinated through the Eastern Regional Technical Advisory Committee (ERTAC) and headed by the Lake Michigan Air Directors Consortium (LADCO), identified a need to better quantify and characterize rail-related emissions inventories. Traditional locomotives largely utilize diesel engines, resulting in emissions of NO_x, diesel PM, hydrocarbons, greenhouse gases, and other pollutants. These emissions are sometimes concentrated in areas exceeding National Ambient Air Quality Standards. No cohesive nationwide railroad emission estimates based on local operations are known to have been made previously. Inventory development methods for locomotive emissions estimates vary from state to state and, in general, lack the spatial or temporal resolution needed to support air quality modeling and planning [1-5].

The ERTAC Rail Subcommittee (ERTAC Rail) was established with active representatives from twelve member states, three regional planning offices, and the US EPA. The subcommittee's goals are to (1) standardize agencies' inventory development methods through a collaborative effort, (2) improve the quality of data received and the resulting emission inventories, and (3) reduce the administrative burden on railroad companies of providing data.

With support from the Rail industry and assistance from the ERTAC Rail Data Workgroup (Appendix A), ERTAC Rail has developed 3 inventories of locomotive emissions (Table 1); from Class I line-haul, Shortline and Regional Railroads (Class II and III operations), and Class I railyard switchers. Because of the difficulty in obtaining data and differences in states' needs for inventory years, sources from both 2007 and 2008 were utilized (Appendix B.) Due to the variability and uncertainty in much of the data, the results are considered applicable for either 2007 or 2008.

The Surface Transportation Board (STB) defines Class I Railroads as having had minimum carrier operating revenues of $401.4 million (USD) in 2008. There are 8 Class I Railroads operating in the United States (Table 2), about 12 Regional Railroads (Class II), and approximately 530 Class III Railroads (Shortlines). While categorized as a Class I Railroad, Amtrak was excluded from these inventories because of significant differences in equipment and operation characteristics. Line-haul locomotives travel long distances (e.g. between cities) while switcher locomotives largely operate in railyards, splitting and joining rail cars with varying destinations. Passenger and Commuter Rail (including Amtrak), industrial locomotives, and associated non-locomotive equipment are not included in these inventories.

This paper documents the data sources and methodologies used for calculating the Class I line-haul emissions inventory. Class I line-haul activities are the largest source of rail-related emissions, with estimates of Class I line-haul fuel consumption totals to be from 74 to 84% of all rail sources combined[4, 5]. For this reason, characterizing Class I line-haul emissions were a focal point of ERTAC Rail's inventory development efforts. Information on ERTAC Rail, Railroad participation, the Rail industry, and effects of rail on air quality are available elsewhere[6].

Table 1. Summary of ERTAC Rail Inventories: U.S. Locomotive Emissions and Fuel Use for either 2007 or 2008*.

	Fuel Use** (gal/yr)	Emissions (tons/yr)					
		NO_x	$PM_{2.5}$	HC	SO_2	CO	NH_3
Class I*** line-haul	3,770,914,002	754,443	23,439	37,941	7,836	110,969	347
Class I switcher	300,492,223	73,741	2,024	4,824	619	9,152	27
Class II and III	157,800,000	51,367	1,163	1,897	357	5,058	16

*See Appendix B for a description of the year and source of data utilized for each inventory.
**Locomotive grade diesel
***Excluding Amtrak and including work train fuel use

Table 2. Class I Railroads, Reported Locomotive Fuel Use, and Railroad Fuel Consumption Index (RFCI) [7].

Class I Railroads*	R-1 Reported Locomotive Fuel Use (gal/yr)		RFCI (ton-miles/gal)
	Line-Haul (2007)**	Switcher (2008)	
BNSF	1,393,874,954	52,497,057	883.14
Canadian National	93,830,751	12,290,022	1190.79
Canadian Pacific***	50,320,233	4,594,067	1096.28
CSX	514,687,186	53,717,674	963.81
Kansas City Southern	69,787,071	1,816,759	785.89
Norfolk Southern	463,267,278	32,317,375	865.75
Union Pacific	1,185,146,529	143,470,336	974.64
Total	**3,770,914,002**	**300,492,223**	**929.47**

* Excluding Amtrak
** Includes work trains
*** CP's line-haul fuel use values include 2008 data (rather than 2007) for their Delaware and Hudson subsidiary.

Method

Earlier efforts to characterize line-haul railroad emissions relied on highly aggregated activity data (Figure 1), and generally apportioned annual system-wide fuel use equally across all route miles of track operated by a Class I railroad. However, the majority of freight tonnage carried by Class I railroads is concentrated on a disproportionately small number of route miles. In addition, emissions calculations were previously based on an estimate of annual nationwide-average locomotive fleet mix to create one set of emissions factors.

For this inventory, the Class I Railroads allowed ERTAC Rail access under a confidentiality agreement to a link-level (single lengths of track) line-haul GIS layer activity dataset managed by the Federal Railroad Administration[9]. Each railroad also provided fleet mix information that allowed ERTAC Rail to calculate weighted emission factors based on the fraction of their line-haul fleet meeting each Tier level category. The use of this data, largely following a line-haul inventory methodology recommended by Sierra Research[2, 3], resulted in a link-level line-haul locomotive emission inventory using railroad-specific emission factors. This segment-level inventory is nationwide, aggregated to state and county level files, and will be released as gridded emissions files for use in photochemical and dispersion modeling. Link-level emissions may be provided for special study requests pending approval of any Class I railroads operating in the study domain. The calculations are described below as a two-part process, calculating railroad-specific factors and emissions per rail link.

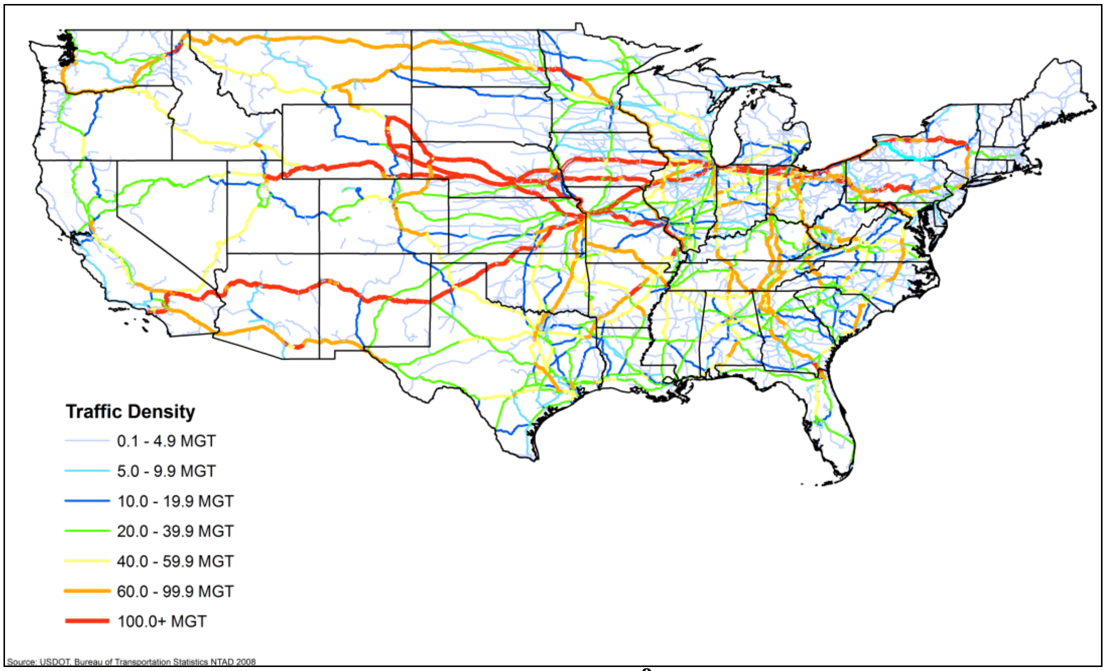

Figure 1. US Railroad Traffic Density in 2006.[8] MGT is million gross tons.

1. Calculate Railroad-Specific Factors.

The EPA provides annual default Emission Factors for locomotives based on characteristic operating cycles ('duty cycles') and the estimated nationwide fleet mixes for both switcher and line-haul locomotives. However, fleet mixes vary from railroad to railroad and, as can be seen in Figure 2, Class I railroad activity is highly regionalized in nature and subject to issues of local terrain such as operation on plains vs. mountainous areas, which can have a significant impact on fuel consumption and emissions.

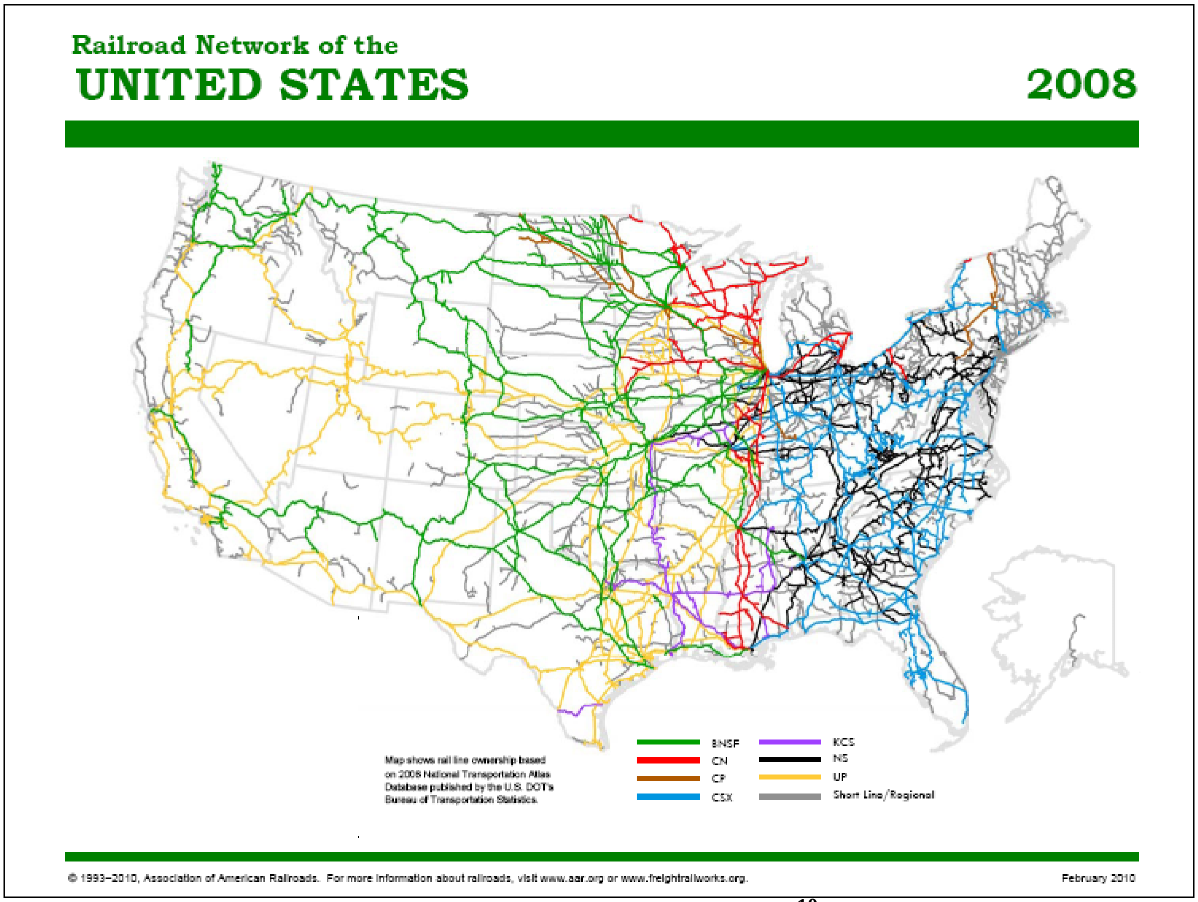

Figure 2. Class I Railroad Territories in the United States[10].

As an alternative approach to using a single nationwide set of emission factors, ERTAC Rail requested each Class I company to provide a description of their line-haul fleet mix based on Tier rating, which each company provided under a confidentiality agreement. An engine's Tier level is based on the year the engine was built and determines allowable emission limits (Table 3).

Table 3. EPA line-haul locomotive Emission Factors by Tier, 1997 standards (grams/gal). Note that the new standards released in 2008 did not apply to fleets in the year 2008. [11]

	PM_{10}	HC	NO_x	CO
Uncontrolled (pre-1973)	6.656	9.984	270.4	26.624
Tier 0 (1973-2001)	6.656	9.984	178.88	26.624
Tier 1 (2002-2004)	6.656	9.776	139.36	26.624
Tier 2 (2005 +)	3.744	5.408	102.96	26.624

Based on values in EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009.

Weighted Emission Factors (EF) per pollutant for each gallon of fuel used (gm/gal or lbs/gal) were calculated for each Class I railroad fleet based on its fraction of line-haul locomotives at each regulated Tier level (Eqn 1; Table 3).

$$EF_{iRR} = \sum_{T=1}^{4} (EF_{iT} * f_{TRR}) \qquad \text{Equation 1}$$

EF_{iRR} = Weighted Emission Factor for pollutant i for Class I railroad RR (gm/gal).
EF_{iT} = Emission Factor for pollutant i for locomotives in Tier T (gm/gal) (Table 3). There were 4 Tiers of locomotives in the 2008 fleets.
f_{TRR} = Fraction of railroad RR fleet in Tier T.

While engine emissions are variable within Tier categories, this approach likely provides better regional estimates than uniformly applying the nationwide average emission factors. This approach likely provides conservative emission estimates as locomotive engines are certified to meet or exceed the emissions standard for each Tier, although emission levels may increase after certification.

Other emission factors are not engine specific. For locomotives, $PM_{2.5}$ is assumed to be 97% of PM_{10} [11], and emission factors applied for SO_2 and NH_3 are 1.88 g/gal [11] and 83.3 mg/gal [12] respectively. Greenhouse gases are estimated using emission factors shown in Table 4.

Table 4. EPA greenhouse gas emission factors for locomotive diesel fuel (grams/gal). [13]

	CO_2	N_2O	CH_4
Locomotive diesel	1.015E4	0.26	0.80

A Railroad Fuel Consumption Index (RFCI) was also calculated for each Class I railroad using their system-wide line-haul fuel consumption (FC) and gross ton-mile (GTM) data reported in their annual R-1 reports submitted to the Surface Transportation Board[7] (Eqn 2). This value represents the average number of GTM produced per gallon of diesel fuel used over their system in a year, and varies between railroad carriers depending on factors such as fleet mix, system terrain, speeds, loading/weight of cargo, train type (e.g., intermodal, unit, and manifest), and operating practices. (Table 2).

$$RFCI_{RR} = \frac{GTM_{RR}}{FC_{RR}} \qquad \text{Equation 2}$$

$RFCI_{RR}$ = Railroad Fuel Consumption Index (gross ton-miles/gal) per Class I railroad (RR).
GTM_{RR} = Gross Ton-Miles (GTM), annual system-wide gross ton miles of freight transported per RR. (R-1 Report Schedule 755, Line 104)
FC_{RR} = Annual system-wide fuel consumption by line-haul and work trains per RR (gal) (R-1 Report Schedule 750, Lines 1 and 6).

2. Calculate Emissions per Link.

Emissions of pollutant i per link L (E_{iL}) are then calculated by multiplying the gallons of diesel fuel consumed by each Class I railroad on the link by that railroad's weighted Emission Factor for the pollutant, and summed over all railroads operating on the link (Eqn 3). This approach splits the activity on each link (represented by MGT) evenly between all railroads operating on the link. Note that the weighted Emission Factors are converted to tons/gal for these calculations, and that variables with units in tons may represent tons of freight hauled (MGT, RFCI) or tons of pollutants (EF, E).

$$E_{iL} = \sum_{RR=1}^{N} \frac{\left(\frac{MGT_L * 10^6}{N}\right) * l_L}{RFCI_{RR}} * EF_{iRR} \qquad \text{Equation 3}$$

E_{iL} = Emissions of pollutant i per link L (tons/year).
N = Number of Class I railroads operating on link L.
MGT_L = Millions of Gross Tons hauled per link per year from the FRA database (10^6 tons/yr)[9].
l_L = Link length from the FRA database (miles).
EF_{iRR} = Weighted Emission Factor for pollutant i per railroad RR (Eqn 1; tons/gal).
$RFCI_{RR}$ = Railroad Fuel Consumption Index per railroad RR (Eqn 2; gross ton-miles/gal).

Note that approximately 36% of Class I route miles in the United States are shared by more than one Class I carrier, a fraction that drops to 26% when neglecting track only shared between one Class I freight railroad and Amtrak. Accurately apportioning the specific fractions of tonnage (MGT) per carrier per link was considered, but after comparing likely worst-case areas, the difficultly of merging carrier-specific MGT with the aggregated FRA MGT dataset was considered too great considering the potential gain in accuracy. Where warranted, MGT data may be apportioned more accurately in the future.

Limitations, Conclusions, and Future Work

Rail-related emissions can be important components of emissions inventories used to support effective air quality management practices, at local, state, regional, and national levels. This line-haul inventory, as well as the companion Class I railyard inventory and Class II/III inventory, greatly improve our estimates of rail-related emissions. However, a systematic study of variability and uncertainty in line-haul locomotive emissions and activity, by fleets, locations, and through time, would give valuable information for identifying how to best improve this inventory as well provide an indication of how representative the inventory may be. An uncertainty study on the data used for this inventory, including the R-1 reported fuel use and the confidential link-level tonnage data, would also help in evaluating the quality of this inventory. Localized studies should also examine how shared tracks are apportioned between multiple carriers.

Early ERTAC Rail discussions concluded that link-level tonnage was the most important data to obtain, while other variables such as track grade and track speed could not be addressed at this time. ERTAC Rail calculated railroad-specific fleet-averaged emission factors rather than applying the estimated national average; however, it is recognized that emissions from individual engines are highly variable even within Tier categories depending on variables such as the specific locomotive model, operation cycle, and conditions of operation. Future evaluation of emission variability within Tiers and between certain types of operation and locations would also be valuable.

Emissions inventory preparation guidance from the U.S. EPA describes locomotive activity as relatively constant throughout the year (e.g. no daily, weekly, or seasonal variability); however, actual activity levels do vary seasonally and annual averaging may dilute or exaggerate concentrations during pollution episodes. ERTAC Rail and the Class I railroad community had some discussions addressing if incorporating more specific fleet mix or monthly or seasonal variation may be worthwhile, and these topics should be looked into further.

Finally, it is important to reiterate that the link-level MGT data maintained by the FRA is proprietary and can only be released to agencies/groups outside the FRA with the express permission of each Class I railroad. It is possible that one or more Class I railroads could withhold permission for access, but data for specialized studies may be provided if requested. This database can also be improved by better distinguishing between haulage and trackage rights, and by apportioning tonnage hauled on links to specific carriers.

We would like to thank the Class I Railroads and their representatives for their assistance and support in the development of this inventory.

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Appendix A: ERTAC Rail Data Workgroup

REPRESENTATIVE	**ORGANIZATION**
Matt Harrell	IL EPA
Michelle Bergin (Co-Chair) and Byeong Kim	GA EPD
Mark Janssen (Co-Chair)	LADCO
Julie McDill and Patrick Davis	MARAMA
Laurel Driver	US EPA OAQPS
Robert Fronczak	AAR
Steven Sullivan	ASLRRA
Rick Nath	CSX
David Seep and Lyle Staley	BNSF
Ken Roberge	CPR
Carl Akins and Peter Conlon	KCS
Erika Akkerman	CN
M. John Germer	UP
Brent Mason and Richard Russell	NS
Joanne Maxwell	Amtrak

Appendix B: Source and Year of Data Utilized for Each Inventory

Data	Year	Source
Class I Line-Haul		
Annual Line-Haul Fuel Use and Gross Ton-Miles	2007	STB R-1 Reports (CP data for D&H is for 2008.)
Line-haul fleet mix for emission factors	2008	Each Class I railroad
Link-level tonnage	2007	FRA confidential database
Class I Railyards (Switcher Locomotives)		
Annual Switcher Fuel Use	2008	R-1 Reports
Switcher fleet mix for emission factors	2008	Each Class I railroad
Link-level tonnage or Density Code (for activity estimate)	2007	FRA confidential database
Class II and III Locomotives		
Annual Total Fuel Use	2008	ASLRRA Annual Report (2008)
Track length and railroad	2008	ASLRRA Annual Report (2008)
Estimated fleet mix for emission factors		Discussions with ASLRRA and Class II and III representatives.

Appendix B

ERTAC Class II/III Line Haul Documentation

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ERTAC – Class 2/3 Shapefile Documentation

13 Jul 2009

Introduction

This document outlines the methods and procedures used to compile a shapefile representing the links in the FRA 1:100,000 railroad dataset that are owned or operated by Class II and III railroad companies. It is important to note that there is a considerable amount of overlap between the Class II's and III's and the Class I and passenger railroads. Class II's and III's can operate on Class I or passenger rail links and vice versa. Although the final shapefile specifically represents Class II and III links, there are many Class I and passenger railroads represented as well.

Procedure

1. Started with all proprietary FRA links where "NET = 'M' and "STCNTYFIPS" <> ' ' (this definition query selects all active mainline links located within the United States).
2. Ran 12 queries, one for each ownership and trackage rights field, to select all links not associated with a Class I freight railroad or Amtrak and not containing a null value (e.g., "RROWNER1" <> 'AMTK' AND "RROWNER1" <> 'BNSF' AND "RROWNER1" <> 'CN' AND "RROWNER1" <> 'CPRS' AND "RROWNER1" <> 'CSXT' AND "RROWNER1" <> 'KCS' AND "RROWNER1" <> 'NS' AND "RROWNER1" <> 'UP' AND "RROWNER1" <> ' '). The first query was setup as a new selection. Each of the 11 subsequent queries were setup to add records to initial set of records. 26,261 links were selected and exported to a new shapefile.
3. Due to the multitude of railroad codes used to represent commuter rail operations across the country, additional processing was required to remove any links that were not operated by a Class II or III freight railroad. Each commuter railroad was queried out of the new shapefile and the links analyzed to eliminate all links where no Class II or III operations were occurring. The following commuter rail operations were evaluated: NJT (New Jersey Transit), MNCW (Metro-North Commuter Railroad), LI (Long Island Railroad), CDOT (Connecticut DOT), MBTA (Massachusetts Bay Transportation Authority), SEPA (Southeastern Pennsylvania Transportation Authority), MARC (Maryland Area Rail Commuter), VRE (Virginia Railway Express), MTRA (Northeastern Illinois Regional Commuter Railroad), CSS (Northern Indiana Commuter Transportation District), DART (Dallas Area Rapid Transit), SCRA (Southern California Regional Rail Authority – including also SCAX, LACM, LAPT, and LATC), TCRA (South Florida Regional Transportation Authority), PJPB (Caltrain), and ACE (Altamont Commuter Express).

Approximately 1581 links were identified with no Class II or III operations and were deleted from the Class 2/3 shapefile.

4. The remaining Class II and III links were then compared to the regional maps contained in the July-August issue of The Official Railway Guide to assess the completeness of the Class 2/3 shapefile. Six specific edits were made to the shapefile to correct the most glaring errors: 1) BMLP links deleted (Black Mesa & Lake Powell, an electric coal hauling railway in Arizona); 2) DSNG links deleted (Durango & Silverton steam tourist railroad in Colorado; 3) CIC haulage rights links on CN from Chicago to Omaha deleted; 4) DMIR links deleted (Duluth, Missabe & Iron Range, now owned and operated by CN in Minnesota; 5) EVWR's ex-CSXT links coded from Evansville, IN to Okawville, IL (Evansville Western Railroad); 6) INRD ex-CP links coded from Chicago, IL to Louisville, IN (Indiana Rail Road).
5. During the course of reviewing the FRA dataset, 555 "active" links were found to have no ownership or trackage rights codes. 1005 links have no codes listed in the 3 ownership fields. In most cases these links are very short and scattered across the country. Only the links representing the EVWR and INRD spanned large distances and were fixed. The other problem links were deemed to be insignificant. A listing of these links will be provided back to the FRA to assist with their coding in 1:100K railway shapefile.

Appendix C

ERTAC Rail Yard Documentation

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ERTAC Rail Emissions Inventory
Part 2: Class I Railyard Switcher Locomotives

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Matthew Harrell, IL Environmental Protection Agency
Mark Janssen, Lake Michigan Air Directors Consortium

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Kansas City Southern	69,787,071	1,816,759
Norfolk Southern	463,267,278	32,317,375
Union Pacific	1,185,146,529	143,470,336
Total	**3,770,914,002**	**300,492,223**

* Excluding Amtrak
** Includes work trains
*** CP's line-haul fuel use values include 2008 data (rather than 2007) for their Delaware and Hudson subsidiary.

This paper documents the data sources and methodologies used for calculating the Class I switcher ("Railyard") inventory. Information on ERTAC Rail, Railroad participation, the Rail industry, and effects of rail on air quality are available elsewhere[6].

Method

Switcher locomotives are expected to be the single largest source of air emissions in railyards. Therefore, as a starting point for a comprehensive railyard inventory, a Class I switcher emission inventory was developed. It is assumed that estimates for yards of interest, associated equipment and activity, and smaller railroads could be refined later.

While ERTAC Rail represents states east of the Mississippi River, the railroad companies specified they wanted this effort to result in a consistent nationwide inventory. ERTAC Rail agreed to calculate emissions for all states when the data was available and when additional significant effort was not required. Because both the dataset of railyards and switcher fuel use was nationwide in scope, the resulting initial railyard inventory is a nationwide, 'top-down' derivation. However, railroad companies may have different levels and quality of data available, and may have interpreted some data requests differently. Also, states are requested to update yards they have detailed information on when possible, and a few states (i.e. California) have unique railroad operations and equipment. Therefore, data for some areas will be more accurate than for others, and locally-derived inventories may be more accurate.

This documentation describes development of the initial top-down inventory, which consisted of three main activities:

1. Locate Class I Railyards
2. Select/Calculate Emission Factors
3. Estimate Locomotive Activity
4. Improve Estimates

1. Locate Class I Railyards.

Identification and correct placement of railyards was an important first step, requiring a comprehensive electronic dataset. A confidential database was obtained from the Federal Railroad Administration (FRA) with permission from the Class I Railroads (FRA database). A similar public database compiled by the Bureau of Transportation Statistics is also available[7] . Data from this source will not match the confidential data exactly, but will be very similar. The FRA database has rail links (track lengths) individually identified as parts of specific railyards. While there may be discrepancies in how each railroad defined railyard links, this dataset appears to identify most Class I railyards in the U.S., and shows a high density of yards in the eastern states (Figure 1). The database gives length, up to 3 owners and 3 operators, and a Federal Density Code (explained below) for each railyard link.

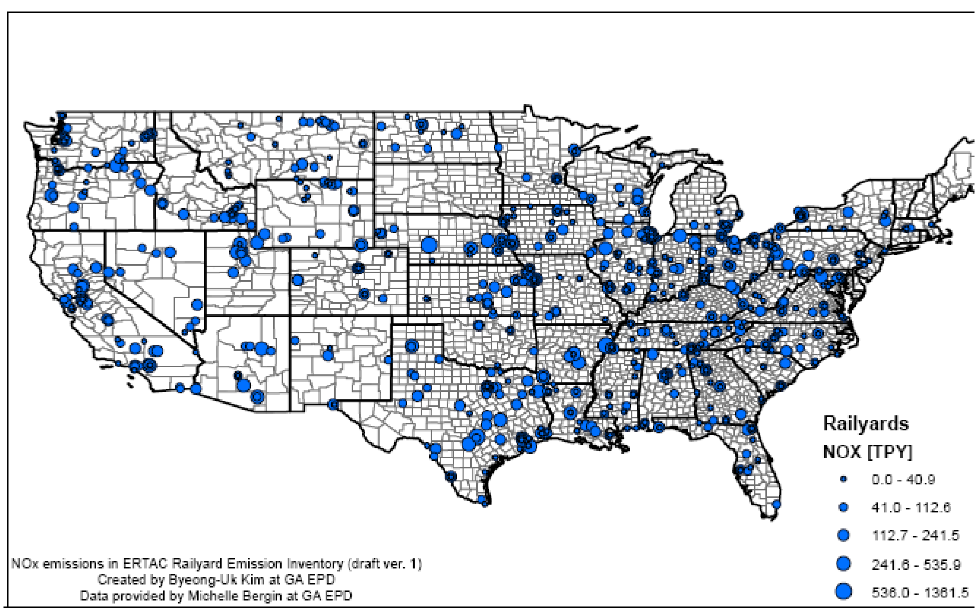

Figure 1. Class I Railyards in the United States and estimates of Annual NOx emissions from switcher locomotives (tons/yr in 2008).

2. Select/Calculate Emission Factors.

The EPA provides annual default emission factors based on characteristic operating cycles ('duty cycles') and the estimated nationwide fleet mix for both switcher and line-haul locomotives. However, switcher fleet mix is not uniform from company to company and, as can be seen in Figure 2, Class I railroad activity is highly regional.

As an alternative approach, ERTAC Rail requested each Class I rail company to provide a description of their switcher fleet mix based on Tier rating, which each company provided under a confidentiality agreement. An engine's Tier determines allowable emission limits based on the year the engine was built (Table 3). While engine emissions are variable within Tier categories, this estimate likely provides a better regional estimate than the nationwide average. The company-specific systemwide fleet mix was used to calculate weighted average emissions factors for switchers operated by each Class I railroad.

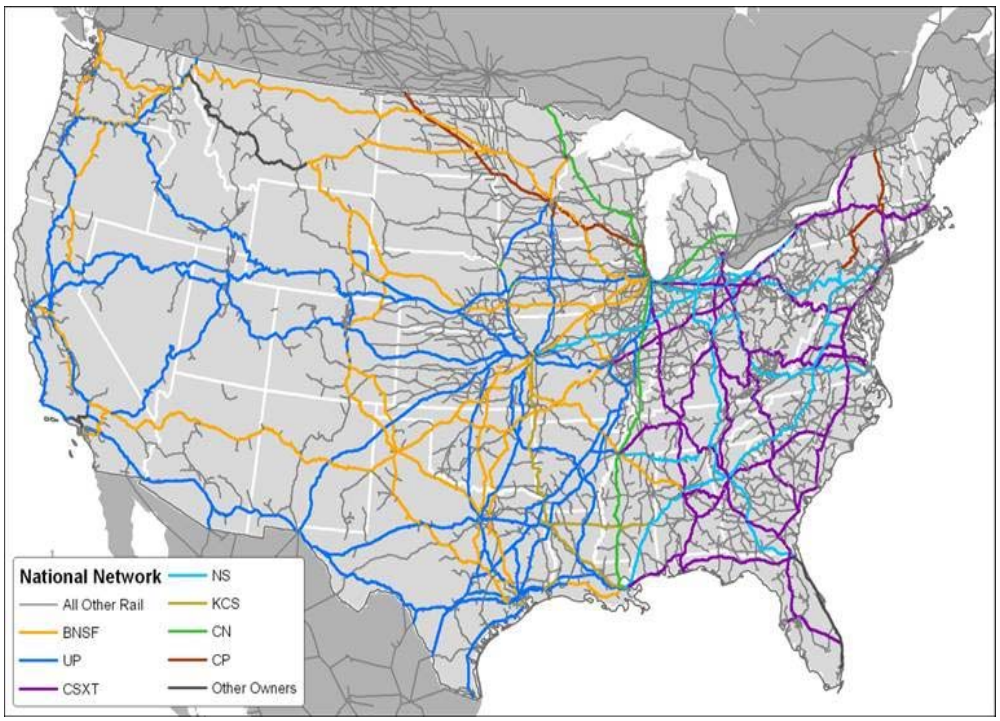

Figure 2. Class I Railroad Territories in the United States.

Table 3. EPA switcher locomotive emission factors by Tier, 1997 standards (grams/gal).

	PM_{10}	**HC**	**NO_x**	**CO**
Uncontrolled (pre-1973)	6.688	15.352	264.48	27.816
Tier 0 (1973-2001)	6.688	15.352	191.52	27.816
Tier 1 (2002-2004)	6.536	15.352	150.48	27.816
Tier 2 (2005 +)	2.888	7.752	110.96	27.816

Listed years apply to the year the engine was built. Table based on values from [8]. Note that the new standards released in 2008 did not apply to existing fleets in the year 2008.

For locomotives, $PM_{2.5}$ is assumed to be 97% of PM_{10} [8], and emission factors for SO_2 and NH_3 are 1.88 g/gal and 83.3 mg/gal respectively (add cites). Greenhouse gases are also estimated using emission factors shown in Table 4.

Table 4. EPA greenhouse gas emission factors for locomotive diesel fuel (grams/gal).

	CO_2	**N_2O**	**CH_4**
Locomotive diesel	1.015E4	0.26	0.80

Source: U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, EPA 430-R-07-002, Annex 3.2, (April 2007), web site: http://www.epa.gov/climatechange/emissions/usinventoryreport.html

These emission factors are based on a characteristic duty cycle for switchers which assumes operation over 24-hour per day 365 days per year. An evaluation of the effect of variability in railyards and switching duties on emissions would be useful for future inventories.

3. Estimate Locomotive Activity.

Class I railroads report total annual switcher locomotive fuel use to the STB, which is reported in publicly available 'R-1' reports (Table 2). There may be inconsistencies between railroads in how fuel use is estimated to be apportioned between line-haul and switcher locomotive use, and possibly in the total locomotive fuel use, so these values may be adjusted in the future. However, the use of these values provides a starting point for estimating total U.S. Class I locomotive-related emissions segregated by Class I carrier. The R-1 report was used by ERTAC for both the line-haul and switcher locomotive emissions inventories.

The next step for inventory development is to allocate switcher fuel use to each railyard. Two methods were applied, one that relies on publicly available line-haul activity (the 'Dencode' method), and the other using confidential line-haul activity (the 'MGT' method.) At this time, Norfolk Southern and Kansas City Southern have provided input for use of the MGT method and the Dencode method is applied for the other five railroads.

The Dencode Method – Publicly available data

Each link in both the publicly available BTS database and the confidential FRA database has a 'Federal Density Code' (Dencode) ranging from 1 to 7 assigned based on the cumulative annual freight tonnage hauled on the link (track). Total Switcher Fuel Use in each railyard Y (SFU_Y) is estimated as follows:

First the Switcher Activity Indicator per yard (SAI_Y) is estimated by multiplying the average dencode of the links identified as part of the same railyard by the sum of the length of the links for that railyard (Eqn 1).

$$SAI_Y = \sum (l_{nY} * FDC_{nY}) \qquad \text{Equation 1}$$

SAI_Y = Switcher Activity Indicator in Railyard Y

n_Y = number of links identified as part of railyard Y
l_{nY} = length of link n in miles
FDC_n = Federal Density Code (1 to 7) of link n

Next, this value is then weighted (SAI_Y') based on an ownership factor (OF) set between 0 and 1. The OF depends on the number of owners listed for each railyard: if there is one owner the OF is set to 1, if there are two owners the primary owner is set to 0.8 and the secondary is 0.2, and if there are 3 owners the primary is 0.6, the secondary is 0.2, and the tertiary is 0.1.

$SAI_Y' = OF_Y * SAI_Y$ Equation 2

Next, the SAI_Y' of all railyards belonging to a Class I railroad (RR) were summed, and the fraction of the railroads total SAI associated with each railyard was multiplied by the railroads total annual switcher fuel use reported in the R-1 (TFU_{RR}), resulting in the total Switcher Fuel Use for each railyard Y (Eqn 2).

$$SFU_Y = \frac{SAI_Y'}{\sum_{RR} SAI_Y'} * TFU_{RR}$$ Equation 3

SFU_Y = Switcher Fuel Use at railyard Y

Finally, the SFU_Y is multiplied by the emission factors described in the previous section to obtain annual switcher emissions at each railyard.

The MGT Method – Confidential data

Two railroads, Norfolk Southern and Kansas City Southern, provided confidential link-level tonnage information and weighting factors to correct skewed estimates to improve estimated switcher activity at important yards. Other railroads may also allow the use of this technique for their inventories in the future.

The MGT Method also uses the FRA database for railyard identification and link lengths. However, rather than using the average dencode per link, confidential annual gross tonnage (MGT) hauled per link in the railyard was used to calculate the railyard switcher activity (SAI_Y). This is calculated by replacing FDC_n in Equation 2 with link-specific tonnage MGT_n (Equation 4).

$$SAI_Y = \sum (l_{nY} * MGT_{nY})$$ Equation 4

SAI_Y = Switcher Activity Indicator in Railyard Y
n_Y = number of links identified as part of railyard Y

l_{nY} = length of link n in miles
MGT_{nY} = million gross tons on link n

This method provides a more refined comparison between railyards than the use of the 7-category dencodes; however, is more susceptible to errors for yards where tonnage is not correlated to switching activity. For example, a yard with large coal trains pulling through used for crews to change over would be assigned an overly high level of emissions for switching activity. To account for this, a discretionary Switching Activity Factor (SAF) was introduced to allow railroads to roughly weight yards with clearly higher or lower levels of switching activity than what results from the mathematical allocation. Therefore, SAI_Y is weighted based on both the ownership factor (OF) as well as the SAF (Equation 5). For example, a yard used for crew changes and not switching may have an SAF of 0, while a yard at a major interchange between cities may have an SAF of 3.

$$SAI_Y' = OF_Y * SAF_Y * SAI_Y \qquad \text{Equation 5}$$

Again, the SAI_Y' of all railyards belonging to a Class I railroad (RR) are summed, and the fraction of the railroads total SAI associated with each railyard was multiplied by the railroads total annual switcher fuel use reported in the R-1 (TFU_{RR}), resulting in the total Switcher Fuel Use for each railyard Y (Eqn 6).

$$SFU_Y = \frac{SAI_Y'}{\sum_{RR} SAI_Y'} * TFU_{RR} \qquad \text{Equation 6}$$

While the SAF allows estimates of yard-specfic emissions to be adjusted, the total level of emissions for each railroad, which is based on systemwide fuel use and systemwide emission factors, remains unchanged. The MGT method SFU_Y is also later multiplied by the emission factors described in the previous section to obtain annual switcher emissions at each railyard.

4. Improve estimates.

In addition to the Switching Activity Factor described above, direct input was also used to improve emission estimates for important railyards. Each Class I railroad provided an estimate of annual average switcher fuel use (generally much lower than the EPA default of 82,490 gal/yr) as well as the name, location, and number of operating switchers for railyards with 8 or more switchers operating in ozone or PM2.5 nonattainment areas. This data was used to overwrite the dencode or MGT derived emissions estimates for those railyards.

The difference in estimated fuel use for those railyards was re-allocated (added or removed) between the remaining railyards belonging to that Class I railroad. It is important to note that there are some discrepancies in how this data was reported for the large railyards by each railroad. For example, some railroads reported all switchers located at a railyard while others reported 'full time equivalent' switchers, meaning the number of switchers normalized to a full working cycle (24-hours per day year-round.) This process should be standardized for future inventory versions.

States also have the option of updating specific railyard emissions estimates. Because this inventory is derived 'top-down', local studies and familiarity with specific railyards is expected to provide better estimates, which can be used to adjust this inventory. Care must be taken to ensure the other railyard estimates are adjusted to account for increases or decreases in estimated fuel use per yard.

Limitations, Conclusions, and Future Work

What this ERTAC Rail railyard inventory does well is provide a comprehensive overview of where railyards are, who owns them, and gives a geographical allocation of switcher emissions bounded by what is reported as nationwide switcher fuel usage by the Class I railroads. These sources can be important for air quality management in nonattainment areas, as well as in regional analysis and for future transportation planning. This inventory will be useful for regional and some local modeling, helps identify where railyards need to be better characterized, and provides a strong foundation for future development of a meaningful nationwide Class I switcher emissions inventory.

There are important uncertainties associated with estimates from this method, including, but not limited to, the use of tonnage hauled as an indicator of the amount of switching activity, and, for a few of the railroads, how the amount of switcher fuel use was determined to be reported in the R-1. The R-1 reported values are currently under examination.

There is also likely significant variability in actual switching duty-cycles and, potentially, in the number of switchers operating at some railyards at different times of the year. 'Road-switching', or the use of what are considered switching locomotives to move between nearby yards, should be addressed in either this or the ERTAC line-haul inventory.

It must be noted that freight-related rail activity is not always routine and no annual emissions inventory will ever be able to capture the innate variability of the source. However, as other large emission sources are reduced, and if rail activity increases as expected, it is important to include our best estimates of these sources in air quality analysis. In the future, on-line data loggers and other tracking technologies, combined with ambient studies and detailed modeling, will hopefully provide more insight to the emissions of locomotives and other railyard sources.

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Appendix: ERTAC Rail Data Workgroup

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1.0 INTRODUCTION

1.1 What is the National Emission Inventory?

The National Emission Inventory (NEI) is a comprehensive inventory covering all anthropogenic sources of criteria pollutants and hazardous air pollutants (HAPs) for all areas of the United States. The NEI was created by the U.S. Environmental Protection Agency's Emission Inventory and Analysis Group (EIAG) in Research Triangle Park, North Carolina. The NEI will be used to support air quality modeling and other activities. To this end, the EPA established a goal to compile comprehensive emissions data in the NEI for criteria and HAPs for mobile, point, and nonpoint sources. This report presents an overview of how emission estimates for the aircraft component of the NEI were compiled.

1.2 Why Did the EPA Create the NEI?

The Clean Air Act (CAA), as amended in 1990, includes mandates for the EPA related to criteria and hazardous air pollutants. The CAA defines criteria pollutants as being one of the following air pollutants:

- Carbon monoxide (CO);
- Sulfur oxides (SO_x);
- Nitrogen oxides (NO_x);
- Ozone; and
- Particulate matter (PM).

Hazardous air pollutants are also delineated in the CAA, see *http://www.epa.gov/ttn/atw/188polls.html* for a complete list of regulated pollutants and their chemical abstract service [CAS] numbers.

The CAA requires the EPA to identify emission sources of these pollutants, quantify emissions, develop regulations for the identified source categories, and assess the public health and environmental impacts after the regulations are put into effect. The NEI is a tool that EPA can use to meet the CAA mandates. In this report, criteria and HAP emission estimates are discussed for aircraft sources.

1.3 How is the EPA Going to Use This Version of the NEI?

It is anticipated that the emission inventory developed from this effort will have multiple end uses. The data have been formatted according to protocols established for the EPA's NEI submittals. The common data structure on which the NEI platform is based will allow the NEI emission data to be transferred to multiple end-users for a variety of purposes.

The criteria and HAP emission estimates developed for the NEI will be used to evaluate air pollution trends, air quality modeling analysis, and impacts of potential regulations.

1.4 Report Organization

Following this introduction, Section 2.0 provides information on how the national aircraft emission estimates were developed. This inventory effort was coordinated by the EPA's Office of Transportation and Air Quality (OTAQ) and EIAG. The appendixes were created to provide the supporting references from OTAQ.

2.0 DEVELOPMENT OF THE AIRCRAFT COMPONENT FOR THE NEI

2.1 How does this aircraft study fit into the NEI?

The NEI was developed to include all point, nonpoint (sometimes referenced as "area"), and mobile sources. The approaches used in the point and nonpoint source categories are documented in other reports. Table 2-1 summarizes the approaches used to estimate emissions from all nonroad sources included in the NEI program. Those source categories and years that are included in this report are noted in bold.

The scope of this inventory component of the NEI was to compile criteria and HAP emissions data for aircraft operating in United States air space. In this effort, national emission estimates were often developed as point sources for each airport. The methodologies used to estimate emissions are discussed in this report.

The target inventory area includes every state in the United States and every county within a state, including Washington, DC, Puerto Rico, and US Virgin Islands. There are no boundary limitations pertaining to traditional criteria pollutant nonattainment areas or to designated urban areas. The pollutants inventoried included all criteria pollutants (and the 188 HAPs identified in Section 112(b) of the CAA).

In addition to numerous specific chemical compounds, the list of 188 HAPs includes several compound groups [e.g., individual metals and their compounds, polycyclic organic matter (POM)]; the NEI includes emission estimates for the individual compounds wherever possible. Many of the uses of the NEI depend upon data (e.g., toxicity) for individual compounds within these groups rather than aggregated data on each group as a whole.

The intent in presenting the following emission inventory approach is to provide sufficient and transparent documentation such that states and local agencies can use these approaches, in conjunction with their specific local activity data to develop more accurate and comparable emission estimates in future submittals.

This documentation is not meant to provide an exhaustive analysis on the derivation of all the inputs. For example, an emission factor used for a national estimate may be given in the appendix, but the source test data that were evaluated to obtain this factor may not be presented or discussed. The goal of the documentation provided is to show in a brief and concise manner how a given estimate was derived.

Table 2-1a. Methods Used to Develop Emission Estimates for Onroad Vehicle Sources

(Years addressed in this report are noted in bold print)

Base Year(s)	Pollutant(s)	Geographic Area	Emission Estimation Method
2008	All Criteria, HAPs	US, Puerto Rico, Virgin Islands	Emission estimates for all pollutants were developed using EPA's National Mobile Inventory Model (NMIM), which uses MOBILE6 (specifically, M6203ChcOxFixNMIM.exe) to calculate onroad emission factors. Where States provided alternate onroad MOBILE6 inputs or VMT, these data replaced EPA default inputs. Default VMT is based on FHWA 2008 data and 2008 Census population estimates.
2005	All Criteria, HAPs	US, Puerto Rico, Virgin Islands	Emission estimates for all pollutants were developed using EPA's NMIM, which uses MOBILE6 to calculate onroad emission factors. Where States provided alternate onroad MOBILE6 inputs or VMT, these data replaced EPA default inputs. Default VMT is based on FHWA 2005 data and 2005 Census population estimates.
2002	All Criteria, HAPs	US, Puerto Rico, Virgin Islands	Emission estimates for all pollutants were developed using EPA's NMIM, which uses MOBILE6 to calculate onroad emission factors. Where States provided alternate onroad MOBILE6 inputs or VMT, these data replaced EPA default inputs. California-supplied emissions data which replaced default EPA emission estimates for this state. Default VMT is based on FHWA 2002 data and population data from 2000 Census.
2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	California	Emissions and VMT provided by California at county/vehicle type level; State-provided emissions expanded to county/SCC level by EPA.
2001	NH_3	California	Calculated at State/county/SCC level by month using MOBILE6 emission factors with State-provided VMT data.
2001	All Criteria	AL; CO; ME; MA; MS; OR; UT; VA; WV; Maricopa County, AZ; Hamilton County, TN	State-provided VMT grown to 2001; emissions calculated by EPA using MOBILE6 emission factors.
2001	All Criteria	Rest of US	Calculated at State/county/SCC level by month using MOBILE6 and FHWA-based VMT.
1999	All Criteria	AL; ME; MA; MS; UT; VA; WV; Maricopa County, AZ; Hamilton County, TN	Calculated at State/county/SCC level by month using MOBILE6; State-provided VMT data used.
1999	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	California	Emissions and VMT provided by California at county/vehicle type level; State-provided emissions expanded to county/SCC level by EPA.
1999	NH_3	California	Calculated at State/county/SCC level by month using MOBILE6 emission factors with State-provided VMT data.
1999	PM_{10} Exhaust	Colorado	PM_{10} emissions and VMT provided by State.

Table 2-1a. Methods Used to Develop Emission Estimates for Onroad Vehicle Sources
(Years addressed in this report are noted in bold print)

Base Year(s)	Pollutant(s)	Geographic Area	Emission Estimation Method
1999	VOC, NO_x, CO, SO_2, PM_{10} brake and tire wear, $PM_{2.5}$, NH_3	Colorado	Calculated at State/county/SCC level by month using MOBILE6; State-provided VMT data used.
1999	All Criteria	Oregon	Emissions and VMT provided by Oregon at county/vehicle type level; State-provided emissions expanded to county/SCC level by EPA.
1999	All Criteria	Rest of US, Puerto Rico, and US Virgin Islands	Calculated at State/county/SCC level by month using MOBILE6 and FHWA-based VMT.
1999	HAPs	California	HAP emissions and VMT provided by California at county/vehicle type level; emissions allocated to SCC level by EPA.
1999	HAPs	Rest of US, Puerto Rico, and US Virgin Islands	MOBILE6 emission factors calculated at State/county/SCC level by season; applied to FHWA-based VMT.
1997-1998	All Criteria	US	2-step linear interpolation at State/count/SCC level based on 1996 and 1999 State/count/SCC level data.
1990, 1996	HAPs	US	MOBILE6 emission factors calculated at State/county/SCC level by season; applied to Federal Highway Administration (FHWA)-based vehicle miles traveled (VMT).
1991-1995	All Criteria	US	Linear interpolation at State/count/SCC level based on 1990 and 1996 State/count/SCC level data.
1988-1989	All Criteria	US	Linear interpolation at State/count/SCC level based on 1987 and 1990 State/count/SCC level data.
1979-1986	All Criteria	US	Linear interpolation at State/count/SCC level based on 1978 and 1987 State/count/SCC level data.
1978, 1987, 1990, 1996, 2000	All Criteria	US	Calculated at State/county/source classification code (SCC) level by month using MOBILE6, no State data incorporated.
1970, 1975	All Criteria	US	Linear extrapolation at national vehicle type level based on 1978 and 1987 national data.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
NONROAD Categories			
Nonroad Gasoline, Diesel, LPG, CNG	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's National Mobile Inventory Model (NMIM), which incorporates NONROAD2008. Where states provided alternate NMIM nonroad inputs, these data replaced EPA default inputs.
	2005	VOC, NO_x, CO, SO_2, , PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's NMIM, which incorporates NONROAD2005. Where States provided alternate nonroad inputs, these data replaced EPA default inputs.
	2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's NMIM, which incorporates NONROAD2004. Where states provided alternate nonroad inputs, these data replaced EPA default inputs. State-supplied emissions data also replaced default EPA emission estimates.
	1999	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) an updated 1999 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. Replaced State-submitted data for California for all NONROAD model categories; Pennsylvania for recreational marine and aircraft ground support equipment, and Texas for select equipment categories.
	1996, 1997, 1998, 2000 & 2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated year-specific national and California inventories, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios and California county-to-state ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. California results replace the diesel equipment emissions generated from prior application of county-to-national ratios.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1990 and 1996 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1990 and 1996. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1990 county-level emissions to estimate 1991-1995 emissions.
	1990	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1990 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1986, 1988, & 1989	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1985 and 1990 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1985 and 1990. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1985 county-level emissions to estimate 1986-1989 emissions.
	1987	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for 1987 by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.
	1985	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1985 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1970, 1975, 1978, & 1980	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for all years by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1996, 1997, 1998, 1999, 2000, & 2001	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD. NH_3 emissions for California were also recalculated using updated diesel fuel consumption values generated for California-specific runs, and assuming the 1996 county-level distribution.
	1985 & 1990	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD.
	1987	NH_3	Obtaining 1987 national fuel consumption estimates from Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1970, 1975, 1978, & 1980	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1990, 1996, & 1999	HAPs	Speciation profiles applied to county VOC and PM estimates. Metal HAPs were calculated using fuel and activity-based emission factors. Some state data were provided and replaced national estimates. (2003)
Aircraft			
Commercial Aircraft	**2008**	**Criteria and HAPs**	**Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)**
	2002 and 2005	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) was run for criteria pollutants, VOC and PM emissions were speciated into HAP components. (2004)
	1990, 1996, 1999, 2000, 2001	VOC, NO_x, CO, SO_x	Input landing and take-off (LTO) data into FAA EDMS. National emissions were assigned to airports based on airport specific LTO data and BTS GIS data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2003)
General Aviation, Air Taxis	**2008**	**Criteria and HAPs**	**Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO for aircraft identified as Air taxis. (2010)** **Used FAA LTO data from TAF and OTAQ provided activity data for smaller airports derived from FAA 5010 master plans. EPA approved generic emission factors for criteria estimates. Speciation profiles were applied to VOC and PM estimates to get national HAP estimates. (2010)**

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
General Aviation, Air Taxis (Continued)	2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2002 emissions for approximately 4,000 largest airports were calculated via EDMS and SIP guidance and included in the 2005 NEI as point sources. Only airports in FAA's T100 and TAF databases were included. State point source submittals were incorporated.
	1978, 1987, 1990, 1996, 1999, 2000, 2001, & 2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to develop national HAP estimates. (2004)
	1990, 1996, 1999, & 2002	Pb	Used Department of Energy (DOE) aviation gasoline usage data with lead concentration of aviation gasoline. (2004)
	1996	NH_3	Applied NH_3 emissions factors to 1996 national jet fuel and aviation gasoline consumption estimates.
Military Aircraft	**2008**	**VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$**	**Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed. (2010)**
	2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2002 emissions were included in the 2005 NEI as point sources similar to other TAF reported data.
	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, 2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed.
	1970-1998	VOC, NO_x, CO, SO_X, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
Auxiliary Power Units and Ground Support Equipment	**2008**	**VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, HAPs**	**Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)**
	2002 and 2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, HAPs	Computed via NONROAD2005 model runs.
	1985-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using LTO operations data from the FAA. Estimation methods prior to 1996 reported in EPA, 1998.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Unpaved Airstrips[1]	1985-2001	PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Aircraft Refueling[1]	1985-2001	VOC	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Commercial Marine Vessel (CMV)			
All CMV Categories	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	OTAQ provided CAP emission estimates for all CMV categories. Note that the SCCs for this category have changed such that the Diesel category refers to smaller vessels (Category 1 and 2) using distillate fuels and the Residual category refers to larger (Category 3) vessels using a blend of residual fuels. Emissions were allocated to segments using GIS shapefiles and adjusted based on limited state data (2010)
	2008	HAPs	OTAQ's 2008 estimates were speciated into HAP components using SEPA profiles (2009)
CMV Diesel	2002 and 2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2001 Estimates carried over. Used state data when provided. (2004)
		HAPs	1999 Estimates carried over. Used state data when provided. (2004)
	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Used criteria emission estimates in the background document for marine diesel regulations for 2000. Adjusted 2000 criteria emission estimates for other used based on fuel usage. Emissions were disaggregated into port traffic and underway activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
	1996	NH_3	Applied NH_3 emissions factors to 1996 distillate and residual fuel oil estimates (i.e., as reported in EIA, 1996).
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
CMV Steam Powered	2005	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$, HAPs	2002 estimates grown to 2005 (2008).
	2002	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$, HAPs	2002 based estimates were developed for port and underway category 3 (C3) vessels as part of a rulemaking effort. Emissions were developed separately for near port and underway emissions. For near port emissions, inventories for 2002 were developed for 89 deep water and 28 Great Lake ports in the U.S. The Waterway Network Ship Traffic, Energy, and Environmental Model (STEEM) was used to provide emissions from ships traveling in shipping lanes between and near individual ports (2008)
	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Calculated criteria emissions based on EPA SIP guidance. Emissions were disaggregated into port traffic and under way activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, & 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
Military Marine	1997-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CMV Coal,[2] CMV, Steam powered, CMV Gasoline[2]	1997-1998	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CM Coal, CMV, Steam powered, CMV Gasoline, Military Marine	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Estimation methods reported in EPA, 1998.
Locomotives			
Class I, II, III and Yard operations	2008	VOC, NO_x, CO, PM_{10}, $PM_{2.5,}SO_x$ & HAPs	Criteria emission estimates were provided to EPA by ERTAC. These data were assigned to individual railway segments using DOT shapefiles and guidance from ERTAC. HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. (2010)

Table 2-1b. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Class I, Class II, Commuter, Passenger, and Yard Locomotives	1978, 1987, 1990, 1996, 1999, 2000, 2000, 2002, & 2005	VOC, NO_x, CO, PM_{10}, $PM_{2.5}$	Criteria pollutants were estimated by using locomotive fuel use data from DOE EIA and available emission factors. County-level estimates were obtained by scaling the national estimates with the rail GIS data from DOT. State data replaced national estimates. (2004)
	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, & 2005	SO_2	SO_x emissions were calculated by using locomotive fuel use and fuel sulfur concentration data from EIA. County-level estimates were obtained by scaling the national estimates with the county level rail activity data from DOT. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. County-level estimates were obtained by scaling the national estimates with the county level rail activity from DOT. State data replaced national estimates. (2004)
	1997-1998	NH_3	Grew 1996 base year emissions using EGAS growth indicators.
	1996	NH_3	Applied NH_3 emissions factors to diesel consumption estimates for 1996.
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Notes:

* Dates included at the end of Estimation Method represent the year that the section was revised.

1 Emission estimates for unpaved airstrips and aircraft refueling are included in the area source NEI, since they represent non-engine emissions.

2 National Emission estimates for CMV Coal and CMV Gasoline were not developed though states and local agencies may have submitted estimates for these source categories.

EPA, 1998. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Factors and Inventory Group, National Air Pollutant Emission Trends, Procedures Document, 1900–1996, EPA-454/R-98-008. May 1998.

2.2 What are Aircraft Sources?

The aircraft source category includes all aircraft types used for public, private, and military purposes. This includes four types of aircraft (EPA, 1992): 1) Commercial; 2) Air Taxis; 3) General Aviation; and 4) Military.

Commercial aircraft include those used for transporting passengers, freight, or both. Commercial aircraft tend to be larger aircraft powered with jet engines. Air Taxis (AT) carry passengers, freight, or both, but usually are smaller aircraft and operate on a more limited basis than the commercial carriers. General Aviation (GA) includes most other aircraft used for recreational flying and personal transportation. Aircraft that support business travel, usually on an unscheduled basis, are included in the category of general aviation.

The national AT and GA fleet includes both jet and piston-powered aircraft. Most of the AT and GA fleet are made up of piston powered aircraft, though smaller business jets can also be found in these categories. According to a 2008 Federal Aviation Administration GA and AT Activity Survey, 66% of all GA and AT activity are powered by piston-powered aircraft and 34% are jet (or turbine) driven. EPA has used this estimate as a national-scale default value in recently published studies investigating lead emissions from aviation sources (EPA, 2008). The piston powered aircraft tend to have higher VOC, PM, and CO emissions and lower NO_X emissions than larger jet-powered aircraft (EPA, 1992). Military aircraft cover a wide range of aircraft types such as training aircraft, fighter jets, helicopters, and jet- and a small number of piston powered planes of varying sizes.

It should be noted that this inventory effort also includes criteria and Hazardous Air Pollutants (HAP) emission estimates for aircraft Auxiliary Power Units (APU) 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.

2.3 What Pollutants are Included in the National Emission Estimates for Aircraft?

Emissions estimates were developed for all criteria pollutants including volatile organic compounds (VOC), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$) and hazardous air pollutants (HAP) (Cook, 1997; Cook, 1998; EPA/FAA, 2009). The HAPs that are included in the national aircraft inventory are shown in Table 2-2 and are based on available test data and accepted emission estimation procedures.

Table 2-2. Aircraft Pollutant List

1,3-Butadiene	Carbon Dioxide	Naphthalene
1-Methylnaphthalene*	Carbon Monoxide	Nitrogen Oxides
2,2,4-Trimethylpentane	Chrysene*	O-xylene*
2-Methylnaphthalene*	Cumene*	Phenanthrene*
Acenaphthene*	Dibenzo[a,h]Anthracene*	Phenol
Acenaphthylene*	Ethyl Benzene	PM_{10} Primary
Acetaldehyde	Fluoranthene*	$PM_{2.5}$ Primary
Acrolein	Fluorene*	Propionaldehyde
Anthracene*	Formaldehyde	Pyrene*
Benz[a]Anthracene*	Hexane*	Styrene
Benzene	Indeno[1,2,3-c,d]Pyrene*	Sulfur Dioxide
Benzo[a]Pyrene*	Lead	Toluene
Benzo[b]Fluoranthene*	Methane*	VOCs
Benzo[g,h,i,]Perylene*	Methanol*	Xylene
Benzo[k]Fluoranthene*	M-xylene*	

* Added to 2008 Inventory

2.4 How Were the Aircraft Emissions Estimated?

EPA has developed guidance for inventorying aircraft emissions associated with an aircraft's landing and takeoff (LTO) cycle. The cycle begins when the aircraft approaches the airport on its descent from cruising altitude, lands, taxis to the gate, and idles during passenger deplaning. It continues as the aircraft idles during passenger boarding, taxis back out onto the runway for subsequent takeoff, and ascent (climbout) to cruising altitude. Thus, the five specific operating modes in an LTO are (EPA, 1992): 1) Approach; 2) Taxi/idle-in; 3) Taxi/idle-out; 4) Takeoff; and 5) Climbout.

The LTO cycle provides a basis for calculating aircraft emissions. During each mode of operation, an aircraft engine operates at a fairly standard power setting for a given aircraft category. Emissions for one complete cycle are calculated using emission factors for each operating mode for each specific aircraft engine combined with the typical period of time the aircraft is in the operating mode.

On March 20, 2009, the EPA posted preliminary LTO data intended to be will use to calculate emissions for review prior to developing the aircraft inventory. State and local agencies were encouraged to review the materials posted at ftp://ftp.epa.gov/EmisInventory/2008_nei/ and provide comments on any necessary corrections to:

- Airport names and locations for approximately 20,000 airports to be included in the Emission Inventory System (EIS) facility inventory;

- Landing and Takeoff (LTO) information that will be used to estimate emissions for each airport;

- Aircraft/engine combinations to link to FAA LTO data including default assumptions and AircraftEngineCodeTypes for EIS submittals; and

- Lead estimates and lead estimation methodology.

This preliminary review by state, local, and tribal groups provided information that EPA used to improve EPA's work. EPA received comments from four states (i.e., Minnesota Pollution Control Agency - Environmental Analysis and Outcomes Division; New Jersey Department of Environmental Protection; Bureau of Air Management, Connecticut Department of Environmental Protection; and Wisconsin Department of Natural Resources (specifically related to Volk Field Air National Guard Base (VOK) in Juneau County Wittman Regional Airport (OSH)) and three local agencies (i.e., Mecklenburg County North Carolina; Ventura County California Air Pollution Control District (Specifically related to Oxnard (OXR), Camarillo (CMA) and Santa Paula (SZP); and - Regional Air Pollution Control Agency (Dayton and Montgomery County Ohio)).

Criteria emission estimates are presented here for four different aircraft types: commercial air carrier, air taxis, general aviation, and military. HAP emission estimates were developed for all aircraft types.

Emissions for commercial air carriers for which detailed aircraft-specific activity data were available, were calculated differently than the other three aircraft categories (See Figure 2-1). Criteria and HAP emissions were estimated for commercial aircraft by applying aircraft make and model (e.g., Boeing 747-200 series) specific LTO activity data from *FAA's Form 41, Schedules T100 and T100(f) Air Carrier Data to the FAA's Emissions and Dispersion Modeling System (EDMS), Version 5.1* (DOT, 2008). It should be noted that due to the reporting requirements of T-100, only commercial activities are included in the dataset, and therefore does not include activity data for non-air carrier applications such as general aviation and military. This distinction lead to a revision to EPA's original aircraft crosswalk table, also known as the aircraft engine type code, used to match aircraft to EDMS aircraft and to account for double counting between the T-100 data and the TAF data. In the revised crosswalk, aircraft that were previously considered general aviation and military based on aircraft model were changed to air taxi and commercial air carrier aircraft types based on the definition of air taxis (i.e., any aircraft that was not considered an air taxi was classified as an air carrier aircraft). The FAA reviewed the cross walk tables and made additional changes that moved some of the larger air taxis to the commercial air carrier category and some of the smaller commercial air carriers to the air taxi category. The revised crosswalk table is provided in an electronic file as supporting data for this study.

Emissions were calculated for each airport individually using airport specific mixing height. The national-scale default values for taxi in and out are seven and nineteen minutes, respectfully. It should be noted that EDMS incorporates the latest aircraft engine emission factors from the International Civil Aviation Organization Engine Exhaust Emissions Data Bank. The EDMS output includes organic HAPs, but not metals.

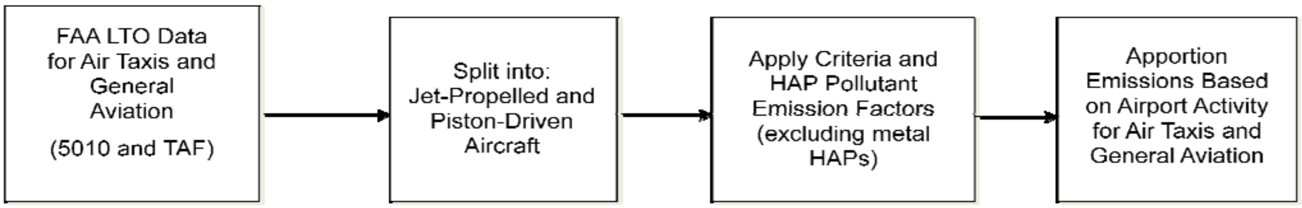

Figure 2-1. Procedures for Estimating Emissions from Commercial Air Carriers

Emissions for GSE and APU associated with commercial air carriers and air taxis for which T-100 data were available were estimated by EDMS, using the assumptions and defaults incorporated in the model. This is significant change from previous NEI year's emissions where GSE estimates came from the NONROAD model and APUs were not included in EPA's estimates. With EDMS, GSE that are assigned to an aircraft are given times (minutes per arrival, minutes per departure) based upon the type of service. For example, a fuel truck servicing a large commercial aircraft will have a different operating time than the same fuel truck servicing a commuter aircraft. All EDMS defaults for GSE duration and type (e.g., fuel truck, cabin service truck, baggage belt loader) were used. GSE emission factors used by EDMS are derived from EPA's NONROAD2005 model and are based on the following variables: fuel, brake horsepower and load factor. GSE engines burn gasoline, diesel, compressed natural gas (CNG), and liquefied petroleum gas (LPG). EPA has used a national-scale value to characterize engines type. The GSE engine distribution is shown below in Table 2-3. Like GSE, APU emissions are the product of operating time. The purpose of an aircraft APU is to provide power to start the main engines and run the heating, cooling, and ventilation systems prior to starting the main engines.

Table 2-3. National-Scale GSE Engine Distribution

GSE Engines Type	Percent of Total
Gasoline Fired, 4-Stroke	16.9
Liquefied Petroleum Gas (LPG) Fired	1.65
Compressed Natural Gas (CNG) Fired	1.25
Diesel Fired	80.2

Emissions of criteria pollutants for air taxis, general aviation, and military aircraft were calculated by combining aircraft operations data from FAA's *Terminal Area Forecasts (TAF) and 5010 Forms.* To avoid double counting between the T-100 data set and the TAF/5010 data, LTOs by airport and aircraft type were summed in the T-100 data and compared with data in the TAF/5010 data. If the TAF/5010 LTO estimates were larger than the T-100 estimates for a specified aircraft type then the T-100 values were subtracted from the TAF/5010 values. If the T-100 values were larger than the TAF values, then the TAF values were set to zero. A data set of adjusted TAF/5010 LTOs were provided to OTAQ where additional adjustments were made to address older data in the TAF and 5010 datasets and to incorporate other insights provided by FAA reviewers.

The TAF/5010 LTO data were dividing into jet and piston powered fractions based on the national observation that 66 percent of all general aviation and air taxi activities are associated with piston powered aircraft and the remaining 34 percent of general aviation and air taxi activities are associated with jet powered aircraft. The adjusted and split TAF/5010 activity data were applied to emission factors as appropriate (See Figure 2-2). It should be noted that EDMS calculates organic HAP emissions in the model (metal HAPs are currently not included in the EDMS output). HAP emission estimates for air taxis, general aviation, and military aircraft were estimated by applying speciation profiles to VOC or PM_{10} emissions estimates. The following equation was used (emission factor are included as Appendix A).

$$E_{ixj} = LTO_i \times FR_{pro\text{-}i} \times EF_{ij}$$

Where:

E_{ixj} = Emission estimate for aircraft type i equipped with engine type x and pollutant j (lbs/year)
LTO_i = Annual count of LTO cycles for aircraft type i
FR_x = Fraction of LTOs equipped with engine type x
EF_{ij} = Generic emission factor for aircraft type i equipped with engine type x and pollutant j (lbs/LTO)
i = Aircraft type (i.e., air taxi, general aviation, and military)
x = Engine type (i.e., jet or turboprop, and piston engine)
j = Criteria pollutant j

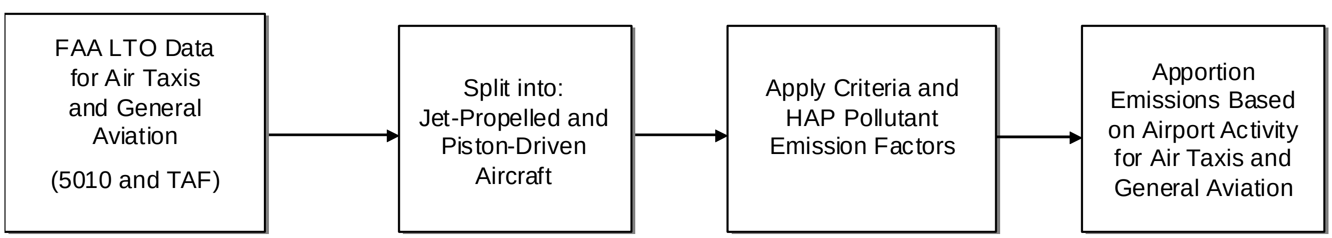

Figure 2-2. Procedures for Estimating Emissions from Commercial Air Taxis and General Aviation

Lead emission estimates were handled differently. Lead emissions are associated with leaded aviation fuel used in piston driven aircraft associated with general aviation. Lead emissions per LTO are calculated using the following equation:

$$Pb(tons) = (\text{piston-engine LTO}) (7.34 \text{ g Pb/LTO}) (0.95) / 907{,}180 \text{ (g/ton)}$$

Where the lead content of aviation gasoline is assumed to be 0.56 grams per liter or 2.12 grams per gallon.

In flight lead emissions were calculate based on national aviation gasoline consumption and similar assumptions noted above about lead fuel content and retention rates. Lead emissions associated with airport LTO activities were subtracted from the national fuel based lead emissions to approximate in flight lead emissions which were allocated to individual counties and noted with the code 777.

For additional details on EPA lead emission calculation procedures see Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory (included in Appendix B).

HAP Emission Estimates

As noted earlier, EDMS calculates organic HAP emissions for aircraft activity reported in the T-100 dataset. Representative HAP speciation profiles were used to estimate the individual chemical species for each aircraft type included in the TAF/5010 dataset. Profiles are used to split (or speciate) organic gases, hydrocarbons, and particulate matter emissions estimates into more individual HAP compounds using the following equation:

$$E_{ixj} = LTO_{ix} \times SP_{ixj}$$

Where:

E_{ixj} = Emission estimate for aircraft type i equipped with engine type x and pollutant j (tons/year)
LTO_{ix} = Annual count of LTO cycles for aircraft type i and engine type x
SP_{ixj} = Generic speciation profiles for aircraft type i equipped with engine type x and pollutant j (tons/LTO)
i = Aircraft type (i.e., air taxi, general aviation, and military)
x = Engine type (i.e., jet or turboprop, and piston engine)
j = Pollutant j

Appendix A contains the HAP profiles converted to emissions factors used for this 2008 inventory. In this version of the NEI aircraft emissions inventory the following corrections to the HAP emission estimates were made:

- Acenpthylene was removed from this inventory for SCC 2275050012.

- To avoid double counting total xylene emissions were removed if speciated xylene factors were also available.

2.5 How Were Emissions Allocated?

For the 2008 inventory, emissions were individually estimated for each airport. A GIS database obtained from the Bureau of Transportation Statistics (BTS) contained airport level data with latitude and longitude coordinates.

2.6 QA/QC

Given the significant methodological changes over previous inventory efforts, several quality checks were implemented to ensure that these data were developed and allocated in a clear and reproducible manner. Some of the quality checks implemented include the following:

Emissions allocations and estimations

- All original data importations and transcriptions into the database were double-checked for errors.
- All calculation methods and approaches were evaluated for technical soundness.
- All unit conversions and equations used to generate results were double-checked for errors.
- All sources of original data are referenced in the spreadsheet.
- Emission factors were compiled from a variety of sources. Each emission factor development methodologies were evaluated to identify the most accurate emission factor for use in this inventory effort.
- Emission sums were evaluated across activity types (e.g., Aircraft, APU, and GSE) to ensure they consistently mirror LTO activity levels.
- 2008 pollutants and emissions were checked against the 2005 inventory to identify any missing pollutants or major changes compared to previous inventories. Discrepancies were investigated and revisions were made as needed.
- The validity of SCC codes, FIP county codes, and pollutant codes were confirmed.
- The validity of Airport and plane identification codes were confirmed.

2.7 What are the Results?

Table 2-4 summarizes the emission estimates for Aircraft, ground support equipment and APUs for criteria pollutants. Table 2-5 summarizes the emission estimates for individual HAPs. Both tables aggregate the data for all states, including the District of Columbia. Note that the 2008 estimates do not include state submitted emissions data.

Table 2-4. Aircraft Criteria Emission Estimates 2008 (tons per year)

Pollutant	2008										
	Military (2275001000)	Commercial (2275020000)	GA, Piston (2275050011)	GA, Turbine (2275050012)	AT, Piston (2275060011)	AT, Turbine (2275060012)	GSE, Gas (2265008005)	GSE, LPG (2267008005)	GSE, CNG (2268008005)	GSE, Diesel (2270008005)	APU (2275070000)
CO	33,161.20	75,463.61	192,510.69	56,532.07	19,116.38	10,180.90	18,005.13	1,768.69	1,398.67	85,607.61	4,072.84
NO_X	284.92	102,561.46	1,041.55	1,911.11	465.64	2,274.10	1,927.90	189.38	149.76	9,166.44	2,841.72
PM_{10}-PRI	709.12	1,782.43	3,792.85	1,397.21	242.12	797.03	55.87	5.49	4.34	265.62	457.11
$PM_{2.5}$-PRI	92.60	1,776.37	493.07	181.64	44.81	103.65	53.63	5.27	4.17	254.97	457.11
SO_2	27.32	10,179.67	160.24	434.33	53.76	439.43	53.21	5.23	4.13	252.99	443.04
VOC	1,652.02	13,608.67	2,399.79	3,223.93	310.48	2,610.94	615.80	60.49	47.84	2,927.89	313.72

Table 2-5. Aircraft HAP Emission Estimates 2008 (tons per year)

Pollutant	2008										
	Military (2275001000)	Commercial (2275020000)	GA, Piston (2275050011)	GA, Turbine (2275050012)	AT, Piston (2275060011)	AT, Turbine (2275060012)	GSE, Gas (2265008005)	GSE, LPG (2267008005)	GSE, CNG (2268008005)	GSE, Diesel (2270008005)	APU (2275070000)
1,3-Butadiene	0.87	184.14	29.75	61.04	5.01	44.44					5.32
1-Methylnaphthalene	0.13	26.96		8.94	0.23	6.20					0.78
2,2,4-Trimethylpentane		0.69	1.09	1.55	0.03	0.51	8.95	0.88	0.69	42.54	
2-methylnaphthalene	0.11	22.48		7.45	0.20	5.17					0.65
Acenaphthene			0.36		0.17						
Acenaphthylene			2.03		0.93						
Acetaldehyde	2.21	466.29	18.82	154.57	11.97	113.00	2.43	0.24	0.19	11.57	13.47
Acrolein	0.02	37.70	1.82	88.61	0.04	32.72					
Anthracene			0.42	6.16E-04	0.19	3.52E-04					
Benz[a]Anthracene		6.09E-04	0.05	9.33E-05	0.02	5.32E-05					
Benzene	0.87	183.48	122.97	60.82	7.58	44.59	10.44	1.03	0.81	49.62	5.30
Benzo[a]Pyrene		4.52E-04	0.05	5.11E-05	0.02	2.91E-05					
Benzo[b]Fluoranthene		8.89E-04	0.06		0.03						
Benzo[g,h,i,]Perylene		8.11E-06	0.13	8.47E-06	0.06	4.83E-06					
Benzo[k]Fluoranthene		8.89E-04	0.06		0.03						
Chrysene		6.17E-04	0.05	8.69E-05	0.02	4.96E-05					

Table 2-5. Aircraft HAP Emission Estimates 2008 (tons per year) (Continued)

Pollutant	2008										
	Military (2275001000)	Commercial (2275020000)	GA, Piston (2275050011)	GA, Turbine (2275050012)	AT, Piston (2275060011)	AT, Turbine (2275060012)	GSE, Gas (2265008005)	GSE, LPG (2267008005)	GSE, CNG (2268008005)	GSE, Diesel (2270008005)	APU (2275070000)
Cumene	2.68E-05	0.05		0.11		0.04					
Ethyl Benzene	1.55E-03	2.68	44.63	6.30	1.05	2.32					
Fluoranthene		1.17E-03	0.45	1.29E-03	0.21	7.35E-04					
Fluorene			0.74		0.34						
Formaldehyde	6.36	1,343.45	81.67	445.41	38.06	327.87	7.20	0.71	0.56	34.23	38.82
Hexane			21.25		0.50						
Indeno[1,2,3-c,d]Pyrene		0.00	0.04		0.02						
Lead **			245.48		8.97						
Methane	0.01				18.96	14.79	14.61	1.44	1.14	69.47	
Methanol	0.02	27.78		65.31		24.11					
m-Xylene	0.14	26.44	0.36	1.58E-04	0.88	3.66	11.09	1.09	0.86	52.74	0.89
Naphthalene	0.28	54.17	21.11	20.42	5.05	13.86					1.71
O-xylene	0.08	15.56	2.03	9.30E-05	1.40	2.19	5.43	0.53	0.42	25.80	0.52
Phenanthrene		0.01	1.25	0.01	0.58	3.27E-03					
Phenol	0.01	11.17		26.27		9.70					
Propionaldehyde	0.38	79.35	1.82	26.30	2.29	19.45	1.48	0.15	0.11	7.04	2.29
Pyrene		1.42E-03	0.61	1.58E-03	0.28	8.99E-04					
Styrene	0.16	33.73	10.32	11.18	1.18	8.25					0.97
Toluene	0.33	70.07	315.76	23.23	8.87	16.77	17.77	1.75	1.38	84.50	2.02
Xylenes (Mixed Isomers)		4.85	177.92	19.04	4.18	6.21					

** The lead estimated provided above represent emissions at individual airports, for 2008, there is an additional 296 tons of lead emitted associated with the combustion of leaded aviation gasoline during in flight operations which is not attributed to airports.

2.8 Aircraft References

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Appendix A

Generic Aircraft Emission Factors/ Speciation Profiles

Commercial Aircraft Emission Factors			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			2.680E-03
VOC			2.934E-03
TOG			3.276E-03
NO_x			9.288E-03
CO			1.119E-02
SO_x			8.910E-04
PM_{10}			5.385E-04
$PM_{2.5}$			5.256E-04
Acetaldehyde	75070	CAA	1.400E-04
Acetone	67641		1.025E-05
Acetylene	74862		1.290E-04
Acrolein	107028	CAA	8.023E-05
Benzaldehyde	100527	IRIS	1.540E-05
Benzene	71432	CAA	5.507E-05
Benzo(a)anthracene	56553		1.297E-09
Benzo(a)pyrene	50328		9.621E-10
Benzo(b)fluoranthene	205992		1.892E-09
Benzo(ghi)perylene	191242		1.726E-11
Benzo(k)fluoranthene	207089		1.892E-09
1,3-Butadiene	101314	CAA	5.527E-05
1-Butene	101389		5.746E-05
Butyraldehyde	123728		3.899E-06
C14-Alkane	No CAS		6.094E-06
C15-Alkane	No CAS		5.799E-06
C16 Branched Alkane	No CAS		4.783E-06
C18-Alkane	No CAS		6.552E-08
C4-Benzene + C3-Aroald	No CAS		2.149E-05
C5-Benzene+C4-Aroald	No CAS		1.061E-05
Chrysene	218019		1.313E-09
Cis-2-Butene	514181		6.880E-06
Cis-2-Pentene	627203		9.042E-06
Crotonaldehyde	4170303		3.384E-05
1-Decene	872059		6.061E-06
Dibenzo(ah)anthracene	53703		2.551E-09
Dimethylnapthalenes	28804888		2.949E-06
Ethane	74840		1.707E-05
Ethylbenzene	100414	CAA	5.701E-06
Ethylene	74851		5.065E-04
Fluoranthene	206440		2.492E-09

Commercial Aircraft Emission Factors			
Pollutant	CAS No.	CAA "187" or IRIS HAP?	Emission Factors (tons/LTO)
Formaldehyde	50000	CAA	4.033E-04
Glyoxal	107222		5.950E-05
Heptene	25339564		1.435E-05
Hexadecane	544763		1.605E-06
1-Hexene	592416		2.411E-05
Indeno(1,2,3-cd)pyrene	193395		2.050E-09
Isopropylbenzene	98828	CAA	9.829E-08
Isovaleraldehyde	514863		1.048E-06
Methacrolein	78853		1.405E-05
Methanol	67561	CAA	5.913E-05
Methyl Glyoxal	78988		4.924E-05
1-Methyl Naphthalene	14120		8.092E-06
2-Methyl Naphthalene	91576	IRIS	6.749E-06
3-Methyl-1-Butene	563451		3.669E-06
4-Methyl-1-Pentene	131372		4.259E-07
2-Methyl-1-Butene	563462		4.587E-06
2-Methyl-2-Butene	513359		6.061E-06
2-Methylpentane	107835		1.337E-05
2-Methyl-1-Pentene	763291		1.114E-06
M-Ethyltoluene	620144		5.045E-06
M-Tolualdehyde	620235		9.108E-06
Naphthalene (gas phase)	91203	CAA	6.084E-06
Naphthalene (solid phase)	91203	CAA	1.260E-06
Napthalene	91203	CAA	1.772E-05
N-Decane	124185		1.048E-05
N-Dodecane	112403		1.514E-05
N-Heptadecane	629787		2.949E-07
N-Heptane	142825		2.097E-06
N-Nonane	111842		2.031E-06
N-Octane	111659		2.031E-06
1-Nonene	124118		8.059E-06
N-Pentadecane	629629		5.668E-06
N-Pentane	109660		6.487E-06
N-Propylbenzene	103651		1.736E-06
N-Tetradecane	629594		1.363E-05
N-Tridecane	629505		1.753E-05
N-Undecane	1120214		1.455E-05
Octene	111660		9.042E-06
O-Ethyltoluene	611143		2.130E-06

Commercial Aircraft Emission Factors			
Pollutant	CAS No.	CAA "187" or IRIS HAP?	Emission Factors (tons/LTO)
O-Tolualdehyde	529204		7.535E-06
1-Pentene	109671		2.542E-05
P-Ethyltoluene	622968		2.097E-06
Phenanthrene	85018		1.112E-08
Phenol	108952	CAA	2.378E-05
Propane	74986		2.555E-06
Propionaldehyde	123386	CAA	2.382E-05
Propylene	115071		1.485E-04
P-Tolualdehyde	104870		1.573E-06
Pyrene	121400		3.028E-09
Styrene	100425	CAA	1.012E-05
Toluene	108883	CAA	2.103E-05
Trans-2-Hexene	4050457		9.829E-07
Trans-2-Pentene	646048		1.176E-05
1,2,3-Trimethylbenzene	526738		3.473E-06
1,2,4-Trimethylbenzene	95636		1.147E-05
1,3,5-Trimethylbenzene	108678		1.769E-06
2,2,4-Trimethylpentane	540841	CAA	1.466E-06
Valeraldehyde	110623		8.027E-06
Xylene	1330207	CAA	1.032E-05

Air Taxi Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			4.37E-04
VOC			5.03E-04
TOG			5.06E-04
NO_x			3.88E-04
CO			1.81E-03
SO_x			8.12E-05
PM_{10}			3.017E-04
$PM_{2.5}$			3.922E-05
Acetaldehyde	75070	CAA	2.160E-05
Acetone	67641		1.583E-06
Acetylene	74862		1.992E-05
Acrolein	107028	CAA	1.238E-05
Anthracene	120127		1.331E-10
Benzaldehyde	100527	IRIS	2.377E-06
Benzene	71432	CAA	8.500E-06
Benzo(a)anthracene	56553		2.014E-11
Benzo(a)pyrene	50328		1.103E-11
Benzo(ghi)perylene	191242		1.829E-12
1,3-Butadiene	101314	CAA	8.531E-06
1-Butene	101389		8.869E-06
Butyraldehyde	123728		6.017E-07
C14-Alkane	No CAS		9.405E-07
C15-Alkane	No CAS		8.950E-07
C16 Branched Alkane	No CAS		7.383E-07
C18-Alkane	No CAS		1.011E-08
C4-Benzene + C3-Aroald	No CAS		3.317E-06
C5-Benzene+C4-Aroald	No CAS		1.638E-06
Chrysene	218019		1.876E-11
Cis-2-Butene	514181		1.062E-06
Cis-2-Pentene	627203		1.396E-06
Crotonaldehyde	4170303		5.224E-06
1-Decene	872059		9.355E-07
Dimethylnapthalenes	28804888		4.551E-07
Ethane	74840		2.635E-06
Ethylbenzene	100414	CAA	8.799E-07
Ethylene	74851		7.818E-05
Fluoranthene	206440		2.784E-10
Formaldehyde	50000	CAA	6.225E-05
Glyoxal	107222		9.183E-06

Air Taxi Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
Heptene	25339564		2.215E-06
Hexadecane	544763		2.478E-07
1-Hexene	592416		3.722E-06
Isopropylbenzene	98828	CAA	1.517E-08
Isovaleraldehyde	514863		1.618E-07
Methacrolein	78853		2.169E-06
Methanol	67561	CAA	9.127E-06
Methyl Glyoxal	78988		7.600E-06
1-Methyl Naphthalene	14120		1.249E-06
2-Methyl Naphthalene	91576	IRIS	1.042E-06
3-Methyl-1-Butene	563451		5.663E-07
4-Methyl-1-Pentene	131372		6.574E-08
2-Methyl-1-Butene	563462		7.079E-07
2-Methyl-2-Butene	513359		9.355E-07
2-Methylpentane	107835		2.063E-06
2-Methyl-1-Pentene	763291		1.719E-07
M-Ethyltoluene	620144		7.787E-07
M-Tolualdehyde	620235		1.406E-06
Napthalene	91203	CAA	2.736E-06
N-Decane	124185		1.618E-06
N-Dodecane	112403		2.336E-06
N-Heptadecane	629787		4.551E-08
N-Heptane	142825		3.236E-07
N-Nonane	111842		3.135E-07
N-Octane	111659		3.135E-07
1-Nonene	124118		1.244E-06
N-Pentadecane	629629		8.748E-07
N-Pentane	109660		1.001E-06
N-Propylbenzene	103651		2.680E-07
N-Tetradecane	629594		2.104E-06
N-Tridecane	629505		2.705E-06
N-Undecane	1120214		2.245E-06
Octene	111660		1.396E-06
O-Ethyltoluene	611143		3.287E-07
O-Tolualdehyde	529204		1.163E-06
1-Pentene	109671		3.924E-06
P-Ethyltoluene	622968		3.236E-07
Phenanthrene	85018		1.238E-09
Phenol	108952	CAA	3.671E-06

Air Taxi Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
Propane	74986		3.944E-07
Propionaldehyde	123386	CAA	3.676E-06
Propylene	115071		2.293E-05
P-Tolualdehyde	104870		2.427E-07
Pyrene	121400		3.401E-10
Styrene	100425	CAA	1.563E-06
Toluene	108883	CAA	3.246E-06
Trans-2-Hexene	4050457		1.517E-07
Trans-2-Pentene	646048		1.815E-06
1,2,3-Trimethylbenzene	526738		5.360E-07
1,2,4-Trimethylbenzene	95636		1.770E-06
1,3,5-Trimethylbenzene	108678		2.731E-07
2,2,4-Trimethylpentane	540841	CAA	1.915E-07
Valeraldehyde	110623		1.239E-06
Xylene	1330207	CAA	2.352E-06

Air Taxi Emission Factors - Piston			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			7.750E-05
VOC			8.484E-05
TOG			9.474E-05
NO_x			7.900E-05
CO			1.407E-02
SO_x			7.500E-06
PM_{10}			3.015E-04
$PM_{2.5}$			3.920E-05
Acenaphthene	83329		2.201E-07
Acenaphthylene	208968		1.242E-06
Acetaldehyde	75070	CAA	5.874E-07
Acrolein	107028	CAA	5.684E-08
Anthracene	120127		2.563E-07
Benzene	71432	CAA	3.837E-06
Benzo(a)anthracene	56553		3.015E-08
Benzo(a)pyrene	50328		3.015E-08
Benzo(b)fluoranthene	205992		3.618E-08
Benzo(ghi)perylene	191242		7.839E-08
Benzo(k)fluoranthene	207089		3.618E-08
1,3-Butadiene	101314	CAA	9.285E-07
Chrysene	218019		3.015E-08
Ethylbenzene	100414	CAA	1.393E-06
Fluoranthene	206440		2.744E-07
Fluorene	86737		4.553E-07
Formaldehyde	50000	CAA	2.548E-06
Indeno(1,2,3-cd)pyrene	193395		2.412E-08
M-Xylene and P-Xylene	108383	CAA	2.201E-07
Naphthalene (gas phase)	91203	CAA	4.327E-07
Naphthalene (solid phase)	91203	CAA	4.432E-06
N-Hexane	110543		6.632E-07
O-Xylene	95476	CAA	1.242E-06
Phenanthrene	85018		7.658E-07
Propionaldehyde	123386	CAA	5.684E-08
Pyrene	121400		3.739E-07
Styrene	100425	CAA	3.221E-07
Toluene	108883	CAA	9.853E-06
2,2,4-Trimethylpentane	540841	CAA	3.394E-08

General Aviation Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			3.00E-04
VOC			2.73E-04
TOG			3.06E-04
NO_x			1.62E-04
CO			4.79E-03
SO_x			3.68E-05
PM_{10}			1.184E-04
$PM_{2.5}$			1.539E-05
Acetaldehyde	75070	CAA	1.309E-05
Acetone	67641		9.593E-07
Acetylene	74862		1.207E-05
Acrolein	107028	CAA	7.506E-06
Anthracene	120127		5.221E-11
Benzaldehyde	100527	IRIS	1.440E-06
Benzene	71432	CAA	5.152E-06
Benzo(a)anthracene	56553		7.903E-12
Benzo(a)pyrene	50328		4.327E-12
Benzo(ghi)perylene	191242		7.178E-13
1,3-Butadiene	101314	CAA	5.170E-06
1-Butene	101389		5.376E-06
Butyraldehyde	123728		3.647E-07
C14-Alkane	No CAS		5.700E-07
C15-Alkane	No CAS		5.425E-07
C16 Branched Alkane	No CAS		4.475E-07
C18-Alkane	No CAS		6.130E-09
C4-Benzene + C3-Aroald	No CAS		2.010E-06
C5-Benzene+C4-Aroald	No CAS		9.930E-07
Chrysene	218019		7.359E-12
Cis-2-Butene	514181		6.436E-07
Cis-2-Pentene	627203		8.459E-07
Crotonaldehyde	4170303		3.166E-06
1-Decene	872059		5.670E-07
Dimethylnapthalenes	28804888		2.758E-07
Ethane	74840		1.597E-06
Ethylbenzene	100414	CAA	5.333E-07
Ethylene	74851		4.738E-05
Fluoranthene	206440		1.092E-10
Formaldehyde	50000	CAA	3.773E-05
Glyoxal	107222		5.566E-06

General Aviation Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
Heptene	25339564		1.342E-06
Hexadecane	544763		1.502E-07
1-Hexene	592416		2.256E-06
Isopropylbenzene	98828	CAA	9.194E-09
Isovaleraldehyde	514863		9.807E-08
Methacrolein	78853		1.315E-06
Methanol	67561	CAA	5.532E-06
Methyl Glyoxal	78988		4.606E-06
1-Methyl Naphthalene	14120		7.570E-07
2-Methyl Naphthalene	91576	IRIS	6.313E-07
3-Methyl-1-Butene	563451		3.433E-07
4-Methyl-1-Pentene	131372		3.984E-08
2-Methyl-1-Butene	563462		4.291E-07
2-Methyl-2-Butene	513359		5.670E-07
2-Methylpentane	107835		1.250E-06
2-Methyl-1-Pentene	763291		1.042E-07
M-Ethyltoluene	620144		4.720E-07
M-Tolualdehyde	620235		8.520E-07
Naphthalene (gas phase)	91203	CAA	1.674E-06
Naphthalene (solid phase)	91203	CAA	5.571E-08
Napthalene	91203	CAA	1.658E-06
N-Decane	124185		9.807E-07
N-Dodecane	112403		1.416E-06
N-Heptadecane	629787		2.758E-08
N-Heptane	142825		1.961E-07
N-Nonane	111842		1.900E-07
N-Octane	111659		1.900E-07
1-Nonene	124118		7.539E-07
N-Pentadecane	629629		5.302E-07
N-Pentane	109660		6.068E-07
N-Propylbenzene	103651		1.624E-07
N-Tetradecane	629594		1.275E-06
N-Tridecane	629505		1.640E-06
N-Undecane	1120214		1.361E-06
Octene	111660		8.459E-07
O-Ethyltoluene	611143		1.992E-07
O-Tolualdehyde	529204		7.049E-07
1-Pentene	109671		2.378E-06
P-Ethyltoluene	622968		1.961E-07
Phenanthrene	85018		4.858E-10

General Aviation Emission Factors - Jet			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
Phenol	108952	CAA	2.225E-06
Propane	74986		2.391E-07
Propionaldehyde	123386	CAA	2.228E-06
Propylene	115071		1.390E-05
P-Tolualdehyde	104870		1.471E-07
Pyrene	121400		1.334E-10
Styrene	100425	CAA	9.470E-07
Toluene	108883	CAA	1.968E-06
Trans-2-Hexene	4050457		9.194E-08
Trans-2-Pentene	646048		1.100E-06
1,2,3-Trimethylbenzene	526738		3.249E-07
1,2,4-Trimethylbenzene	95636		1.073E-06
1,3,5-Trimethylbenzene	108678		1.655E-07
2,2,4-Trimethylpentane	540841	CAA	1.313E-07
Valeraldehyde	110623		7.509E-07
Xylene	1330207	CAA	1.612E-06

General Aviation Emission Factors - Piston			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			7.750E-05
VOC			7.524E-05
TOG			8.537E-05
NO_x			3.250E-05
CO			6.007E-03
SO_x			5.000E-06
PM_{10}			1.184E-04
$PM_{2.5}$			1.539E-05
Acenaphthene	83329		1.123E-08
Acenaphthylene	208968		6.339E-08
Acetaldehyde	75070	CAA	5.874E-07
Acrolein	107028	CAA	5.684E-08
Anthracene	120127		1.308E-08
Benzene	71432	CAA	3.837E-06
Benzo(a)anthracene	56553		1.539E-09
Benzo(a)pyrene	50328		1.539E-09
Benzo(b)fluoranthene	205992		1.846E-09
Benzo(ghi)perylene	191242		4.000E-09
Benzo(k)fluoranthene	207089		1.846E-09
1,3-Butadiene	101314	CAA	9.285E-07
Chrysene	218019		1.539E-09
Ethylbenzene	100414	CAA	1.393E-06
Fluoranthene	206440		1.400E-08
Fluorene	86737		2.323E-08
Formaldehyde	50000	CAA	2.548E-06
Indeno(1,2,3-cd)pyrene	193395		1.231E-09
M-Xylene and P-Xylene	108383	CAA	1.123E-08
Naphthalene (gas phase)	91203	CAA	4.327E-07
Naphthalene (solid phase)	91203	CAA	2.262E-07
N-Hexane	110543		6.632E-07
O-Xylene	95476	CAA	6.339E-08
Phenanthrene	85018		3.908E-08
Propionaldehyde	123386	CAA	5.684E-08
Pyrene	121400		1.908E-08
Styrene	100425	CAA	3.221E-07
Toluene	108883	CAA	9.853E-06
2,2,4-Trimethylpentane	540841	CAA	3.394E-08

Military Emission Factor			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
THC			6.170E-04
VOC			6.815E-04
TOG			7.597E-04
NO_x			7.900E-05
CO			1.407E-02
SO_x			7.500E-06
PM_{10}			3.017E-04
$PM_{2.5}$			3.922E-05
Acetaldehyde	75070	CAA	3.245E-05
Acetone	67641		2.378E-06
Acetylene	74862		2.993E-05
Acrolein	107028	CAA	1.861E-05
Benzaldehyde	100527	IRIS	3.571E-06
Benzene	71432	CAA	1.277E-05
1,3-Butadiene	101314	CAA	1.282E-05
1-Butene	101389		1.333E-05
Butyraldehyde	123728		9.041E-07
C14-Alkane	No CAS		1.413E-06
C15-Alkane	No CAS		1.345E-06
C16 Branched Alkane	No CAS		1.109E-06
C18-Alkane	No CAS		1.519E-08
C4-Benzene + C3-Aroald	No CAS		4.984E-06
C5-Benzene+C4-Aroald	No CAS		2.461E-06
Cis-2-Butene	514181		1.595E-06
Cis-2-Pentene	627203		2.097E-06
Crotonaldehyde	4170303		7.848E-06
1-Decene	872059		1.405E-06
Dimethylnapthalenes	28804888		6.837E-07
Ethane	74840		3.958E-06
Ethylbenzene	100414	CAA	1.322E-06
Ethylene	74851		1.175E-04
Formaldehyde	50000	CAA	9.352E-05
Glyoxal	107222		1.380E-05
Heptene	25339564		3.328E-06
Hexadecane	544763		3.723E-07
1-Hexene	592416		5.591E-06
Isopropylbenzene	98828	CAA	2.279E-08
Isovaleraldehyde	514863		2.431E-07
Methacrolein	78853		3.259E-06

Military Emission Factor			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
Methanol	67561	CAA	1.371E-05
Methyl Glyoxal	78988		1.142E-05
1-Methyl Naphthalene	14120		1.876E-06
2-Methyl Naphthalene	91576	IRIS	1.565E-06
3-Methyl-1-Butene	563451		8.509E-07
4-Methyl-1-Pentene	131372		9.876E-08
2-Methyl-1-Butene	563462		1.064E-06
2-Methyl-2-Butene	513359		1.405E-06
2-Methylpentane	107835		3.100E-06
2-Methyl-1-Pentene	763291		2.583E-07
M-Ethyltoluene	620144		1.170E-06
M-Tolualdehyde	620235		2.112E-06
Napthalene	91203	CAA	4.110E-06
N-Decane	124185		2.431E-06
N-Dodecane	112403		3.510E-06
N-Heptadecane	629787		6.837E-08
N-Heptane	142825		4.862E-07
N-Nonane	111842		4.710E-07
N-Octane	111659		4.710E-07
1-Nonene	124118		1.869E-06
N-Pentadecane	629629		1.314E-06
N-Pentane	109660		1.504E-06
N-Propylbenzene	103651		4.026E-07
N-Tetradecane	629594		3.160E-06
N-Tridecane	629505		4.064E-06
N-Undecane	1120214		3.373E-06
Octene	111660		2.097E-06
O-Ethyltoluene	611143		4.938E-07
O-Tolualdehyde	529204		1.747E-06
1-Pentene	109671		5.895E-06
P-Ethyltoluene	622968		4.862E-07
Phenol	108952	CAA	5.515E-06
Propane	74986		5.926E-07
Propionaldehyde	123386	CAA	5.523E-06
Propylene	115071		3.445E-05
P-Tolualdehyde	104870		3.647E-07
Styrene	100425	CAA	2.348E-06
Toluene	108883	CAA	4.877E-06
Trans-2-Hexene	4050457		2.279E-07
Trans-2-Pentene	646048		2.727E-06

Military Emission Factor			
Pollutant	**CAS No.**	**CAA "187" or IRIS HAP?**	**Emission Factors (tons/LTO)**
1,2,3-Trimethylbenzene	526738		8.053E-07
1,2,4-Trimethylbenzene	95636		2.659E-06
1,3,5-Trimethylbenzene	108678		4.102E-07
Valeraldehyde	110623		1.861E-06

Appendix B

Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory

Calculating Piston-Engine Aircraft Airport Inventories for Lead for the 2008 National Emissions Inventory
December 2010

Section 1. Introduction

The main purpose of this document is to describe the methods the Environmental Protection Agency (EPA) used to calculate airport lead (Pb) inventories for the 2008 National Emissions Inventory (NEI).[1] These methods focus on the development of approaches to estimate piston-engine aircraft activity at airports in the U.S. since the activity of this fleet is reported to the Federal Aviation Administration (FAA) as general aviation (GA) or air taxi (AT) activity – categories that also include jet-engine aircraft activity. The methods described here reflect improvements to the methods used in developing the airport-specific piston-engine aircraft inventories in the 2002 NEI and the 2005 NEI.

Background information regarding the use of leaded aviation gasoline (avgas) in piston-engine powered aircraft is available in other documents.[2,3] Briefly, most piston-engine aircraft operations fall into the categories of either GA or AT. Aircraft used in GA and AT activities include a diverse set of aircraft types and engine models and are used in a wide variety of applications.[4] Lead emissions associated with GA and AT aircraft stem from the use of one hundred octane low lead (100LL) avgas. The lead is added to the fuel in the form of tetraethyl lead (TEL). This lead additive helps boost fuel octane, prevent engine knock, and prevent valve seat recession and subsequent loss of compression for engines without hardened valves. Today, 100LL is the most commonly available type of aviation gasoline in the United States.[5] Lead is not added to jet fuel that is used in commercial aircraft, most military aircraft, or other turbine-engine powered aircraft. Lead emissions from the use of leaded avgas comprised 45% of the national inventory for emissions of lead in 2002.[6]

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[1] In this document '2008 NEI' refers to 2008 NEI version 1 (January 2011), available at http://www.epa.gov/ttn/chief/net/2008inventory.html
[2] EPA (2007) Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information. OAQPS Staff Paper. EPA-452/R-07-013 November 2007. pp 2-8 and 2-9.
[3]FAA William J. Hughes Technical Center http://www.tc.faa.gov/act4/insidethefence/2006/0609_06_AvFuels.htm
[4] Commercial aircraft include those used for scheduled service transporting passengers, freight, or both. Air taxis fly scheduled and for-hire service carrying passengers, freight or both, but they usually are smaller aircraft than those operated by commercial air carriers. General aviation includes most other aircraft (fixed and rotary wing) used for personal transportation, business, instructional flying, and aerial application.
[5] ChevronTexaco (2005) Aviation Fuels Technical Review. FTR-3. http://www.chevronglobalaviation.com/docs/aviation_tech_review.pdf
[6] U.S. Environmental Protection Agency (2008) EPA's Report on the Environment EPA/600/R-07/045F. Available at: http://www.epa.gov/roe

This document is organized into eight sections. Section 2 describes the data we use to calculate the national inventory for the amount of lead released to the air from the combustion of leaded avgas. Section 3 describes the landing and takeoff data we use to calculate airport-specific inventories for lead. Section 4 describes how we estimate landing and takeoff data for the airport facilities that do not report it to the FAA. Section 5 describes the estimate of landing and takeoff activity occurring at heliports in the U.S. Section 6 describes the methods used to calculate the airport-specific inventories for lead. Section 7 describes data that would be needed to improve the estimates of airport-specific inventories for lead and Section 8 describes the estimates of the amount of lead emitted in-flight that are in the 2008 NEI.

In this document, units of tons (i.e., U.S. short tons) are used when discussing the national and airport-specific lead inventory in order to be consistent with the manner in which the NEI reports inventories for lead and other pollutants. The unit of grams is used in describing the concentration of lead in avgas and in describing emission factors. Conversion factors are provided for clarity.

Section 2. Calculating the National Avgas Lead Inventory

Because lead is a persistent pollutant and accumulates in the environment, we include all lead emissions from piston-engine aircraft in the NEI – emissions occurring during the landing and take-off cycle at airports as well as emissions occurring at altitude.[7] To calculate the national avgas lead inventory, we use information provided by the U.S. Department of Transportation's (DOT's) Federal Aviation Administration (FAA) regarding the volume of leaded avgas consumed in the U.S. in 2008.[8] The U.S. Department of Energy's (DOE's) Energy Information Administration (EIA) provides information regarding the volume of leaded avgas produced in a given year. EPA has historically used the DOE EIA avgas fuel volume produced to calculate national lead inventories from the consumption of leaded avgas. However, since EPA uses DOT airport activity and aircraft data, we are using the DOT fuel volume data in the 2008 NEI to calculate the national lead inventory in order to use a consistent data source. In this document, when we refer to avgas fuel volume data it is data supplied by DOT, except where noted.

As demonstrated in the equation below, to calculate the annual emission of lead from the consumption of leaded avgas, we multiply the volume of avgas used by the concentration of lead in the avgas, minus the small amount of lead that is retained in the engine, engine oil and/or exhaust system. The volume of avgas used in the U.S. in 2008

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[7] U.S. EPA, 2006. Air Quality: Criteria for Lead: 2006; EPA/600/R-5/144aF; U.S. Government Printing Office, Washington, DC, October, 2006.

[8] U.S. Department of Transportation Federal Aviation Administration Aviation Policy and Plans. FAA Aerospace Forecast Fiscal Years 2010-2030. p.99. Available at: http://www.faa.gov/data_research/aviation/aerospace_forecasts/2010-2030/media/2010%20Forecast%20Doc.pdf This document provides historical data for 2000-2008 as well as forecast data.

was 248,100,000 gallons.[9] The concentration of lead in avgas ([Pb] in the equation below) can be one of four levels (ranging from 0.14 to 1.12 grams of lead per liter) as specified by the American Society for Testing and Materials (ASTM). By far the most common avgas supplied is "100 Low Lead" or 100LL.[10,11] The maximum lead concentration specified by ASTM for 100LL is 0.56 grams per liter or 2.12 grams per gallon.[12] A fraction of lead is retained in the engine, engine oil and/or exhaust system which we currently estimate at 5%.[13]

For the 2008 NEI, the national estimate of lead emissions from the consumption of avgas was 551 tons (see equation below).

$$\frac{(248{,}100{,}000\ \text{gal})(2.12\ \text{g Pb/gal})(0.95)}{907{,}180\ \text{g/ton}} = 551\ \text{tons Pb}$$

As described above, DOE's EIA also provides estimates of the annual volume of leaded avgas produced in a given year. For 2008, the volume of avgas produced in the U.S. was 5,603 thousand barrels or 235,326,000 gallons.[14] Consumption of this volume of avgas equates to a national lead emissions estimate for this source of 522 short tons.

Section 3. Landing and Takeoff Data Sources and Uses

Airport-specific inventories require information regarding landing and takeoff (LTO) activity by aircraft type.[15] According to FAA records, there are approximately 20,000 airport facilities in the U.S., the vast majority of which are expected to have activity by piston-engine aircraft that operate on leaded avgas. Of these facilities, EPA's NEI has in the past, reported emissions of lead (and other criteria pollutants and

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9 U.S. Department of Transportation Federal Aviation Administration Aviation Policy and Plans. FAA Aerospace Forecast Fiscal Years 2010-2030. p.99. Available at: http://www.faa.gov/data_research/aviation/aerospace_forecasts/2010-2030/media/2010%20Forecast%20Doc.pdf This document provides historical data for 2000-2008 as well as forecast data.

10 ChevronTexaco (2005) Aviation Fuels Technical Review. FTR-3.

11 The 2008 General Aviation Statistical Databook & Industry Outlook report by General Aviation Manufactures Association (GAMA) found that over 90% of avgas is 100LL.

12 ASTM International (2005) Annual Book of ASTM Standards Section 5: Petroleum Products, Lubricants, and Fossil Fuels Volume 05.01 Petroleum Products and Lubricants (I): D 56 – D 3230.

13 The information used to develop this estimate is from the following references: (a) Todd L. Petersen, Petersen Aviation, Inc, *Aviation Oil Lead Content Analysis*, Report # EPA 1-2008, January 2, 2008, available at William J. Hughes Technical Center Technical Reference and Research Library at http://actlibrary.tc.faa.gov/ and (b) E-mail from Theo Rindlisbacher of Switzerland Federal Office of Civil Aviation to Bryan Manning of U.S. EPA, regarding lead retained in engine, September 28, 2007.

14 DOE Energy Information Administration. Fuel production volume data obtained from http://tonto.eia.doe.gov/dnav/pet/hist/mgaupus1A.htm accessed November 2006.

15 An aircraft operation is defined as any landing or takeoff event, therefore, to calculate LTOs, operations are divided by two. Most data sources from FAA report aircraft activity in numbers of operations which, for the purposes of calculating lead emissions using the method described in this document, need to be converted to LTO events.

hazardous air pollutants) at 3,410 airports.[16] While the 3,410 airport facilities are among the most active in the U.S., they comprise only a small fraction of the total airport facilities where leaded avgas is used.

FAA's Office of Air Traffic provides a complete listing of operational airport facilities in the National Airspace System Resources (NASR) database. The electronic NASR data report, referred to here as the 5010 airport data report, can be generated from the NASR database and is available for download from the FAA website.[17] This report is updated every 56 days. EPA obtains airport information (including operations) for a subset of the facilities in the NASR database from FAA's Terminal Area Forecast (TAF) database that is prepared by FAA's Office of Aviation Policy and Plans.[18] The TAF database currently includes information for airports in FAA's National Plan of Integrated Airport Systems (NPIAS), which identifies airports that are significant to national air transportation. Approximately 500 of the airports that are in the TAF database have either an FAA air traffic control tower or an FAA contract tower where controllers count operations. The operations data from the control towers is reported to The Operations Network (OPSNET)[19] which is publically available in the Air Traffic Activity System (ATADS) database.[20] The operations data for the towered airports that is reported in OPSNET and ATADS is then reported to the TAF database. The operations data for the airports in the TAF database that do not have control towers represent estimates.[21] The operations supplied in the 5010 airport data report for facilities not reported in the TAF may be self-reported by airport operators through data collection accomplished by airport inspectors who work for the State Aviation Agency, or operations data can be obtained through other means.[22]

The 5010 airport data report supplies the date that the associated operations data represents.[23] Because airports that are not in the TAF database submit data voluntarily to FAA for the 5010 data report, many of the airports have operations data that represent data for years earlier than 2008. Nationally, GA and AT piston-engine operations have decreased in recent years,[24] therefore EPA did not use operations data from years prior to 2008 as it is reported. Instead, EPA multiplied the older GA and AT piston-engine data (Section 6 describes the method EPA used to calculate the number of piston-engine

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[16] These 3,410 facilities are the facilities for which the FAA's Terminal Area Forecast (TAF) database provides information regarding aircraft activity. The TAF database is prepared by FAA's Office of Aviation Policy and Plans and includes information for the airports in FAA's National Plan of Integrated Airport Systems (NPIAS). One of the goals of the NPIAS is to identify airports that are significant to national air transportation.

[17] http://www.faa.gov/airports_airtraffic/airports/airport_safety/airportdata_5010/

[18] http://aspm.faa.gov/main/taf.asp

[19] http://aspm.faa.gov/opsnet/sys/

[20] http://aspm.faa.gov/opsnet/sys/Airport.asp

[21] FAA's Terminal Area Forecast Summary (Fiscal Years 2009 – 2030), Appendix A (page 28) http://www.faa.gov/data_research/aviation/taf_reports/media/TAF%20Summary%20Report%20FY%202009%20-%202030.pdf

[22] In the absence of updated information from States, local authorities or Tribes, we are using the LTO data provided in the FAA database.

[23] The 12-month ending date on which annual operations data in the report is based.

[24] http://www.faa.gov/data_research/aviation_data_statistics/general_aviation/

operations from total GA and AT activity data) by scaling factors that were calculated by dividing the 2008 national amount of avgas produced by the national amount of avgas produced in the year the operations data represents.[25] A table with the scaling factors is provided in Appendix A. The national volume of avgas produced data comes from the DOE, EIA website and is available for 1981 – 2009.[26] For operations data older than 1981, EPA divided the 2008 national amount of avgas produced by the average of the national amount of avgas produced from 1981 – 1989. Jet engines do not use avgas, therefore EPA did not apply scaling factors to the turbine operations for data from years prior to 2008.

EPA also obtains operations data from the T-100 segment data from the Bureau of Transportation Statistics (BTS). The aircraft in the T-100 data are matched to aircraft in the FAA's Emission and Dispersion Modeling System (EDMS) using the crosswalk table developed for earlier versions of the NEI. Generally the T-100 data covers commercial air carrier operations, but some AT activities are included in the data set that would double count with the TAF data at the same airport. To correct for possible double counting, first the AT LTOs included in the T-100 data were compiled using the aircraft type data included in the aircraft make/models crosswalk.[27] The resulting aggregated LTOs were compared with the reported TAF LTOs for airports where there were overlaps. The T-100 AT LTOs were then subtracted from the TAF AT data to ensure that double counting was minimized. Note that if the T-100 AT value was larger than the TAF value, the TAF value was set to zero to eliminate the possibility of negative LTOs in the dataset.

The 2008 draft NEI was developed using the January 15, 2009 version of the 5010 airport data report. In that version of the report there were 19,925 airport facilities in the U.S. that had submitted data to the FAA. Among these 19,925 facilities, 99 facilities were not relevant for the purposes of estimating lead emissions because they were either listed as closed (85) or they were balloonports (14).[28] Therefore, lead inventories were needed for 19,826 facilities. In the January 15, 2009 version of the 5010 airport data report there were 5,654 airport facilities for which operations data were provided (many of which are facilities in FAA's TAF database).[29] There were 14,172 facilities in the 5010 airport data report for which there were no operations data.[30] As a

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[25] The FAA General Aviation and Air Taxi (Part 135) Activity Surveys (source of national level piston-engine operations data) are only available annually, starting in 1999. Because there are airports with operations data older than 1999, EPA used avgas product supplied data as a surrogate for piston-engine operations to estimate the change in piston-engine activity over the last three decades.

[26] http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=mgaupus1&f=A. DOT recently changed the way they estimate fuel consumption data, so while EPA used DOT data to determine the 2008 national avgas lead inventory, for the purpose of calculating these scaling factors EPA used DOE's data in order to have historical fuel data that is calculated in a consistent manner.

[27] The T-100 data does not specify that the operations data is air taxi in nature; however, in discussions with FAA, EPA determined that these flights are air taxi in nature and has assigned them in the 2008 NEI as such.

[28] Balloon craft do not use avgas

[29] Either Commuter, GA Itinerant, GA Local, or Air Taxi operations data, as these operations can be performed by piston-engine aircraft.

[30] No Commuter, GA Itinerant, GA Local, or Air Taxi operations data.

part of the review process for the draft 2008 NEI, EPA received updated airport data from states and also looked at more recent versions of the 5010 airport data report to update the status of airports, so the number of airports for which EPA estimated activity is slightly lower in the 2008 NEI than in the draft 2008 NEI. The following section of this document describes the method EPA used to estimate operations for the 14,132 airport facilities in the 2008 NEI that do not have reported activity data.

As described in Section 1, most piston-engine aircraft fall into the categories of either GA or AT. Some GA and AT activity is conducted by turboprop and turbojet aircraft which do not used leaded avgas. There are no national databases that provide airport-specific LTO activity data for piston-engine aircraft separately from turbojet and turboprop aircraft. The databases described above report total GA and AT activity conducted by both piston-engine and jet-engine aircraft. Part *(a)* in Section 6 describes how we estimate piston-engine LTOs at airports in the 2008 NEI.

Section 4. Estimating LTOs at the 14,132 Airport Facilities with No LTO Data

FAA has used regression models to estimate operations at facilities where operations data are not available.[31,32] In this work and other work, FAA identified characteristics of small towered airports for which there were statistically significant relationships with operations at these airports.[33] Regression models based on the airport characteristics were then used to estimate general aviation operations for a set of non-towered airports. The airport characteristics identified by FAA and used to estimate general aviation operations at small airports include: the number of aircraft based at a facility (termed 'based aircraft'), population in the vicinity of the airport, airport regional prominence, per capita income, region, and the presence of certificated flight schools.

In the 2000 report titled 'Model for Estimating General Aviation Operations at Non-towered Airports,' a model of GA annual activity was developed using information from small towered airports to explain GA activity at towered and non-towered airports. The model explained GA activity at the towered airports well (R^2 of 0.75) but produced higher estimates than state-supplied estimates for non-towered airports.[34]

The relevant data available in the 5010 airport data report for the purposes of estimating airport operations include: facility type (airport, balloonport, seaplane base, gliderport, heliport, stolport,[35] ultralight); number of GA aircraft based at each airport by

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[31] Federal Aviation Administration, Office of Aviation Policy and Plans, Statistics and Forecast Branch. July 2001. Model for Estimating General Aviation Operations at Non-towered Airports Using Towered and Non-towered Airport Data. Prepared by GRA, Inc.

[32] Mark Hoekstra, "Model for Estimating General Aviation Operations at Non-Towered Airports" prepared for FAA Office of Aviation Policy and Plans, April 2000.

[33] GRA, Inc. "Review of TAF Methods," Final Report, prepared for FAA Office of Aviation Policy and Plans under Work Order 45, Contract No. DTFA01-93-C-00066, February 25, 1998.

[34] The mean absolute difference between the model operations estimate and the state operations estimate was 16,940 operations.

[35] Stolport is an airport designed with STOL (Short Take-Off and Landing) operations in mind, normally having a short single runway.

type (glider, helicopter, jet engine, military, multi-engine, single engine, ultralight); operations data (air taxi, commercial, commuter, GA itinerant, GA local, military)[36]; and operations date (12-month ending date on which annual operations data is based). Census data was also merged with the 5010 airport data report to give population data for each airport's county.

Using the FAA work referenced above, we explored relationships among the airport data variables that best predicted aircraft activity (LTOs). We found that based aircraft was a highly significant and positive regressor to LTOs. Table 1 shows that for facilities that did not have LTO data in the January 15, 2009 version of the 5010 airport data report, 7,856 had based aircraft data while 6,316 did not have based aircraft data.[37, 38] Therefore, as described below, LTO estimates were derived using different methods depending on data availability.

Table 1: Contingency table describing the numbers of airport facilities that have or do not have LTO data and/or based aircraft data for airport facilities in the January 15, 2009 version of the 5010 airport data report

		HAVE LTO DATA		
		YES	**NO**	
HAVE BASED AIRCRAFT DATA	**YES**	4,872	7,856	**12,728**
	NO	782	6,316	**7,098**
		5,654	**14,172**	**19,826**

[36] As explained in footnote 15, an aircraft operation is defined as any landing or takeoff event, therefore, to calculate LTOs, operations are divided by two. The 5010 airport data report from FAA reports aircraft activity in numbers of operations which, for the purposes of calculating Pb emissions using the method described in the TSD, are converted to LTO events.

[37] As described in Section 3, the number of facilities with no LTO data changed slightly from the draft 2008 NEI to the 2008 NEI. In the 2008 NEI, of the facilities that did not have reported activity data, 7,837 facilities reported based aircraft data and 6,295 did not report based aircraft data.

[38] These numbers include data for the following types of facilities: airports, balloonports, seaplane bases, gliderports, heliports, stolports, and ultralights.

(a) Estimating LTOs at Facilities with Based Aircraft Data, but No LTO Data:

There are 6,414 facilities in the 2008 NEI (not including heliports) for which the 5010 airport data report supplies the number of based aircraft[39] but not activity data to which the regression equation (based aircraft vs. LTOs) could be applied. Using the 4,872 airports for which both LTO and aircraft data is known, the initial relationship found between based aircraft and LTOs was:

Equation 1:

LTOs = 2494 + 208*aircraft $R^2 = 0.55$

The FAA models found population to be another significant regressor. We used the population of the county in which the airport is located as the population variable. Adding county population to the model gave the following relationship:

Equation 2:

LTOs = 2204 + 194*aircraft + 0.0038*county population $R^2 = 0.56$

EPA received numerous comments to the docket on its Advance Notice of Proposed Rulemaking on Lead Emissions from Piston-Engine Aircraft Using Leaded Aviation Gasoline[40] indicating that aviation in Alaska is different than it is in the continental U.S. Commenters pointed out that in Alaska, 82% of communities are not accessible by road and rely on air transport for life sustaining goods and services.[41] Commenters also noted that Alaskans travel by air eight times more often per capita than those in the continental U.S. For those reasons, we added a dummy variable in equation 3 to identify whether or not an airport is located in Alaska. Because the relationship between based aircraft and LTOs is likely different for Alaskan airports than it is for airports that aren't in Alaska, we also added an interaction term to equation 3 (interaction of an airport being in Alaska and its sum of based aircraft).

Equation 3:

LTOs = 1937 + 205*aircraft + 0.0038*county population + 566*Alaska – 108*(AlaskaXaircraft)

$R_2 = 0.58$

After analyzing the data and plot for the data underlying equation 3, we found many airport facilities identified as commercial airports for which based aircraft was extremely low (i.e., less than 10), yet LTOs were quite high (i.e., anywhere from 100,000

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[39] Based aircraft for this purpose was limited to single- and multi-engine aircraft, helicopters, and ultralights since these aircraft types can use leaded avgas.

[40] U.S. Environmental Protection Agency (2010) Advance Notice of Proposed Rulemaking on Lead Emissions From Piston-Engine Aircraft Using Leaded Aviation Gasoline. 75 FR 22440 (April 28, 2010).

[41] Comments to the docket on EPA's Advance Notice of Proposed Rulemaking on Lead Emissions from Piston-Engine Aircraft Using Leaded Aviation Gasoline from the Alaska Air Carriers Association (dated 18 June 2010; comment number OAR-2007-0294-0323.1) and Alaska Governor Parnell (dated 25 August 2010; comment number OAR-2007-0294-0403.1).

to more than 200,000 LTOs/year).[42] These facilities were removed from the regression analysis. Additionally, for reasons described below, heliports were also removed from the regression. The resulting relationship was:

Equation 4:

LTOs = 1293 + 203*aircraft + 0.0019*county population - 473*Alaska – 144*(AlaskaXaircraft) $R^2 = 0.65$

When equation 4 was applied to the 6,414 airport facilities that report based aircraft data but not LTO activity, the resulting sum of LTOs was almost 15 million. EPA estimates that the number of LTOs at the airports that do not report activity data should approximate the number of LTOs from the bottom of the distribution of the set of airports that report activity data to the 5010 airport data report but that are not in the TAF database. The average number of LTOs per year from airports in the bottom 30% of the set of airports that report activity data to the 5010 airport data report but that are not in the TAF database is ~63 LTOs/year. Multiplying 63 by the number of airports that do not report activity data equals 549,050 LTOs.[43] Therefore, EPA used equation 4 to generate the distribution of LTOs at the individual airports that report based aircraft data but not activity data and then applied a scaling factor of 0.0356 to those LTOs to obtain the LTOs that are reported in the 2008 NEI.[44] The sum of the LTOs from this set of airports plus the sum of the LTOs at the airports that do not report either based aircraft or activity data (described below in section *(b)*) sum to 549,050 LTOs. These LTOs are all assigned to the GA, piston-engine category since they are assigned to smaller general aviation airports that are assumed to have little to no air taxi or jet aircraft activity.

Equation 4 and the scaling factor were used to estimate LTO activity for the 2008 NEI at airport facilities that report based aircraft data but not activity data.

(b) Estimating LTOs at Facilities with Neither Based-Aircraft Data nor LTO Data:

There are 2,260 facilities (not including heliports) for which the 5010 airport data report supplies neither the number of based aircraft nor activity data. In the absence of data to establish a relationship to airport activity, we assign a default value of LTOs to the GA, piston-engine category for each of these facilities.

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[42] From FAA's website, "Addresses for Commercial Service Airports", available at: http://www.faa.gov/airports_airtraffic/airports/planning_capacity/passenger_allcargo_stats/addresses/media/commercial_service_airports_addresses.xls

[43] This rounded number is calculated by multiplying 63.298 LTOs/year by 8,674, which is the number of airports that don't report activity data (6,414 don't report activity data and 2,260 facilities don't report activity or based aircraft data).

[44] The scaling factor was calculated by dividing 528,710 LTOs by 14,862,767 LTOS; the 528,710 LTOs are equal to 549,050 LTOs minus 20,340 LTOs (20,340 LTOs represent the sum of LTOs assigned to the 2,260 facilities that don't report either activity data or based aircraft data - the derivation of LTO estimates for these facilities is described in Section 4 *(b)*). The 14,862,767 LTOs are the sum of LTOs that result from applying equation 4 to the 6,414 facilities with based aircraft data but no activity data.

The default value was determined by evaluating GA LTOs that are reported at the set of 2,471 facilities that report activity data to the 5010 airport data report but that are not in the TAF set of airports. The average number of LTOs reported to the bottom ten percent of these facilities (when sorted by total GA LTOs) was 9. These facilities are assumed to most closely approximate the set of 2,260 facilities that do not report any based aircraft or LTO data; therefore, we assigned 9 LTOs to the GA, piston-engine category for these airport facilities for purposes of developing inventory estimates.

Section 5. Calculating LTOs at Heliports:

There were 5,559 heliport facilities in the January 15, 2009 FAA 5010 data report that were operational. Of those, only 92 (or 2%) reported LTO data, and of those, only 31 reported both based aircraft and LTO data. Because of the limited information regarding activity at heliports, some municipalities have hired contractors to survey activity in their local area.[45, 46]

The summary statistics for LTO data provided at the 92 operational heliports is presented in Table 2. These facilities report a wide range in activity from 3 LTOs/year to more than 18,000 LTOs/year. Some facilities clearly have significant helicopter traffic (i.e., thousands of LTOs/year) which is supported by the contractor summaries of heliport activity in the Washington Metropolitan area. The little data available to us suggests that the median helicopter activity is less than 200 LTOs/year. In the absence of more information on which to base estimates of LTO activity, we assigned 141 LTOs (the median of the reported heliport LTOs) to the GA category at all of the heliports which do not report LTO data. The piston-engine fraction developed in Section 6 is applied to the 141 LTOs resulting in 51 LTOs assigned to the GA, piston-engine category and 90 assigned to the GA, turbine-engine category. This is an area of significant uncertainty in the inventory and one for which EPA is seeking information from local agencies.

Table 2: Heliport LTO Data for those Reporting LTO Data in the January 15, 2009 Version of the 5010 Airport Data Report

18,250	Maximum LTOs
3	Minimum LTOs
1,123	Average LTOs
141	Median LTOs
50	Mode LTOs

[45] Executive Summary: Regional Helicopter System Plan, Metropolitan Washington Area, prepared by Edwards and Kelcey for the Metropolitan Washington Council of Governments, 2005.
[46] Alaska Aviation Emission Inventory, prepared by Sierra Research, Inc. for Western Regional Air Partnership, 2005.

Section 6. Methodology for Estimating Airport-Specific Lead Emissions

In 2008, EPA developed a method to calculate lead emissions at airports where piston-engine powered aircraft operate. [47] This method brings lead inventories into alignment with the manner in which other criteria pollutants emitted by aircraft are calculated. This method is described here with changes that were made from previous methods (i.e., the method used to develop the 2002 inventory) and applied in developing airport lead inventories for the 2008 NEI. In this section we first present the equation used to calculate lead emitted during the LTO cycle then we describe each of the components of the input data: we describe how we calculate piston-engine LTOs from data available in FAA databases, we describe the derivation of the emission factor for the amount of lead emitted during the LTO cycle, and we describe the estimate of the amount of lead retained in the engine and oil that we do not include in the amount of lead released to the air.

Historically, where aircraft specific activity data are available (such as T-100), aircraft gaseous and particulate matter (PM) emissions have been calculated through the FAA's EDMS.[48] This modeling system was designed to develop emission inventories for the purpose of assessing potential air quality impacts of airport operations and proposed airport development projects. However, EDMS has a limited number of piston-engine aircraft in its aircraft data and is currently not set up to calculate metal emissions and thus, it is not a readily available tool for determining airport lead inventories related to aircraft operations. In developing this approach to determine piston-engine aircraft lead emissions, EPA relied upon the basic methodology employed in EDMS. This requires as input the activity of piston-engine aircraft at a facility, fuel consumption rates by these aircraft during the various modes of the LTO cycle and time in each mode (taxi/idle-out, takeoff, climb-out, approach, and taxi/idle-in), the concentration of lead in the fuel and the retention of lead in the engine and oil. The equation used to calculate airport-specific lead emissions during the LTO cycle is below, followed by a description of each of the input parameters.

$$\text{LTO Pb (tons)} = \frac{\text{(piston-engine LTO)(avgas Pb g/LTO)(1-Pb retention)}}{\text{907,180 g/ton}}$$

(a) Calculating Piston-engine LTO:

Piston-engine LTOs are used to calculate emissions of lead that are assigned to the airport facility where the aircraft operations occur. An aircraft operation is defined as any landing or takeoff event, therefore, to calculate LTOs, operations are divided by two. Most data sources from FAA report aircraft activity in numbers of operations which, for the purposes of calculating lead emissions, need to be converted to LTO events. We

[47] U.S. EPA (2008) Lead Emissions from the Use of Leaded Aviation Gasoline in the United States, Technical Support Document. EPA420-R-08-020. Available at: www.epa.gov/otaq/aviation.htm.
[48] EDMS available from http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/

describe here the method used to estimate the fraction of GA and AT LTOs at an airport that are conducted by piston-engine aircraft. These fractions are calculated separately (one fraction for GA and one for AT). These fractions are multiplied by total LTOs reported separately for GA and AT and then summed to arrive at the total LTOs conducted by piston-engine aircraft at an airport.

One use of the 2008 NEI is to identify sources of lead, including airports, that have inventories of 0.50 tons per year or more for the purposes of identifying locations where lead monitoring may be required to evaluate compliance with the National Ambient Air Quality Standard for Lead. To calculate the most airport-specific inventories for airports that may potentially exceed this inventory threshold, we used a more airport-specific surrogate for this subset of airports than the remainder of the airports where we applied national default averages described below.

We used the fraction of based aircraft at an airport that are single- or multi-engine to calculate the number of GA LTOs at an airport that were conducted by piston-engine aircraft. The data regarding the population of based aircraft at an airport is available for a subset of airports in the FAA 5010 master records data report described in Section 3. For example, if an airport reports 150 single-engine aircraft, 20 multi-engine aircraft and a total of 180 aircraft based at that facility, then the fraction of based aircraft we would use as a surrogate for piston-engine aircraft is 94% ((150+20)/180). We then multiply the total GA LTOs for that facility by 0.94 to calculate piston-engine LTOs.

We evaluated this surrogate by comparing the results of using it with piston-engine aircraft operations reported for airports that supply this information in master plans, airport layout plans, noise abatement studies and/or land use compatibility plans. We could rarely find data from the same year for comparison purposes; however, for the majority of airports, based aircraft and actual observed piston-engine aircraft activity agreed within ten percent.[49]

For the majority of airports in the 2008 NEI we used national average fractions of GA and AT LTOs conducted by piston-engine aircraft that were derived using FAA's General Aviation and Part 135[50] Activity Surveys – CY 2008 (GAATA).[51] Table 2.4 in the 2008 GAATA Survey reports that approximately sixty-six percent (66%) of all GA and AT LTOs are from piston-engine aircraft which use avgas, and about thirty-four

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[49] Documents used to evaluate the use of based aircraft include the following:

Airport Master Plan Update Prescott Municipal Airport (Ernest A Love Field) (2009) Available at: www.cityof**prescott**.net/_d/amp_tablecontents.pdf

Gillespie field Airport Layout Plan Update Narrative Report (2005) Available at: www.co.san-diego.ca.us/dpw/**airport**s/powerpoints/pdalp.pdf

Land Use Compatibility Plan for the Grand Forks International Airport (2006) Available at: www.gfk**airport**.com/authority/pdf/**land_use**.pdf

McClellan-Palomar Land Use Compatibility Plan (Amended March 4, 2010) Available at: www.ci.oceanside.ca.us/.../**McClellan-Palomar**_ALUCP_03-4-10_amendment.pdf

[50] On-demand (air taxi) and commuter operations not covered by Part 121

[51] The FAA GAATA is a database collected from surveys of pilots flying aircraft used for general aviation and air taxi activity. For more information on the 2008 GAATA, see Appendix A at http://www.faa.gov/data_research/aviation_data_statistics/general_aviation/CY2008/

percent (34%) are turboprop and turbojet powered which use jet fuel, such as Jet A. The LTO data in Table 2.4 in the 2008 GAATA Survey does not distinguish LTOs as GA or AT, and thus does not allow us derive separate piston activity fractions for GA and AT.

We are using the number of hours flown by piston versus turboprop or turbojet aircraft (reported in Table 1.4 in the 2008 GAATA Survey) to allow us to make separate estimates of the fraction of GA activity conducted by piston aircraft and the fraction of AT activity conducted by piston aircraft. We chose to use the fraction of hours flown by piston-engine aircraft as a surrogate to calculate the fraction of LTOs flown by piston aircraft since the overall (i.e., for GA and AT combined) piston percent of hours flown (66.4%) is very close to the percent of LTOs that are piston (65.7%). Table 1.4 of the 2008 GAATA presents the total hours flown by aircraft type and separates GA from AT. Seventy-three percent (73%) of all GA hours flown are by piston-engine aircraft while twenty-eight percent (28%) of all GA hours flown are by turboprop and turbojet powered aircraft.[52] Twenty-three percent (23%) of all AT hours flown are by piston-engine aircraft while seventy-seven percent (77%) of all AT hours flown are by turboprop and turbojet powered aircraft. Approximately 5,000 of the total 20,000 airport facilities in the U.S. are heliports at which only helicopters (rotocraft) operate. Therefore, EPA also calculated the percent of rotocraft hours flown that are conducted by piston-engine aircraft. Thirty-six percent (36%) of all GA rotocraft hours flown are by piston-engine rotocraft while sixty-four percent (64%) of all GA rotocraft hours flown are by turboprop and turbojet powered rotocraft. Two percent (2%) of all AT rotocraft hours flown are by piston-engine rotocraft while ninety-eight percent (98%) of all AT rotocraft hours flown are by turboprop and turbojet powered rotocraft. Table 3 identifies the piston and turbine fractions that were used in the absence of airport-specific information to calculate piston-engine operations at airports and heliports in the 2008 NEI.

Table 3: Piston and Turbine Activity Fractions used in the 2008 NEI

	Airports		**Heliports**	
	GA	**AT**	**GA**	**AT**
Piston Powered	72.5%	23.1%	36.1%	2%
Turbine Powered	27.5%	76.9%	63.9%	98%

[52] Numbers in the text may not add to 100% due to rounding; the percentages in Table 3 are the values we used to calculate the 2008 NEI.

(b) Calculating the Piston-engine Aircraft Emission Factor: Grams of Lead Emitted per LTO:

Piston-engine aircraft can have either one or two engines. EDMS version 5.0.2 contains information on the amount of avgas used per LTO for some single and twin-engine aircraft. The proportion of piston-engine LTOs conducted by single- versus twin-engine aircraft was taken from the FAA's GAATA Survey for 2008 (90% of LTOs are conducted by aircraft having one engine and 10% of LTOs by aircraft having two engines).[53] Since twin-engine aircraft have higher fuel consumption rates than those with single engines, a weighted-average LTO fuel usage rate was calculated to apply to the population of piston-engine aircraft as a whole. For the single-engine aircraft, the average amount of fuel consumed per LTO was determined from the six types of single piston-engine aircraft within EDMS.[54] This was calculated by averaging the single-engine EDMS outputs for fuel consumed per LTO using the EDMS scenario property of ICAO/USEPA Default - Times in Mode (TIM), with a 16 minute taxi-in/taxi-out time according to EPA's *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, 1992.[55] This gives a value of 16.96 pounds of fuel per LTO (lbs/LTO). The average single-engine fuel consumption rate was divided by the average density of 100LL avgas, 6 pounds per gallon (lbs/gal), producing an average fuel usage rate for single-engine piston aircraft of 2.83 gallons per LTO (gal/LTO). This same calculation was performed for the two twin-engine piston aircraft within EDMS, producing an average LTO fuel usage rate for twin-engine piston aircraft of 9.12 gal/LTO.

Using these single- and twin-engine piston aircraft fuel consumption rates, a weighted average fuel usage rate per LTO was computed by multiplying the average fuel usage rate for single-engine aircraft (2.83 gal/LTO) by the fleet percentage of single-engine aircraft LTOs (90%). Next, the twin-engine piston aircraft average fuel usage rate (9.12 gal/LTO) was multiplied by the fleet percentage of twin-engine aircraft LTOs (10%). By summing the results of the single- and twin-engine aircraft usage rates, the overall weighted-average fuel usage rate per LTO of 3.46 gal/LTO was obtained.

To calculate the emission factor, the concentration of lead in fuel is multiplied by the fuel consumption per LTO. The maximum lead concentration specified by ASTM for 100LL is 0.56 grams per liter or 2.12 grams per gallon. This amount of lead is normally added to assure that the required lean and rich mixture knock values are achieved. Multiplying this lead concentration in avgas by the weighted average fuel usage rate produces an overall average value of 7.34 grams of lead per LTO (g Pb/LTO) for piston-engines: 3.46 gal/LTO x 2.12 g Pb/gal = 7.34 g Pb/LTO.

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[53] The LTOs from the categories of 1-engine fixed wing piston, piston rotocraft, experimental total, and light sport were summed to determine the total number of single-engine piston aircraft LTOs.

[54] EPA understands that EDMS 5.0.2 has a limited list of piston-engines, but these are currently the best data available.

[55] U.S. EPA, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA-450/4-81026d (Revised), 1992.

(c) Retention of Lead in Engine and Oil (1-Pb Retention):

Data collected from aircraft piston-engines operating on leaded avgas suggests that about 5% of the lead from the fuel is retained in the engine and engine oil.[56] Thus the emitted fraction is 0.95. This information is used in calculating airport-specific lead inventories and will be used to develop future national estimates of lead emitted from the consumption of leaded avgas.

Applying these parameters in the equation above yields the following equation:

$$\text{Pb(tons)} = \frac{\text{(piston-engine LTO) (7.34 g Pb/LTO) (0.95)}}{\text{907,180 g/ton}}$$

which simplifies to:

$$\text{Pb(tons)} = \text{(piston-engine LTO)}\ (7.7 \text{ X } 10^{-6})$$

Where piston-engine LTO[57] = (GA LTO x 0.725) + (AT LTO x 0.231)

(d) Estimating Lead Emissions from Piston-Engine Helicopters:

The emission factor for helicopters (g Pb/LTO) was determined in the same manner as described above for piston-engine fixed-wing aircraft. The concentration of lead in avgas (2.12 g/gal) was multiplied by the weighted average fuel usage rate for four types of Robinson helicopter engines.[58] This produced an overall average emission factor of 6.60 grams of lead per LTO (g Pb/LTO) for piston-engine powered helicopters.

There are no national databases that provide heliport-specific LTO activity data for piston-engine powered helicopters separately from turbine-engine powered helicopters. The 2008 FAA GA and Part 135 Activity (GAATA) Survey reports that approximately 36% of all GA helicopter hours flown are by piston-engine aircraft which use avgas, and about 64% are by turbine-engine powered which use jet fuel (which does

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[56] The information used to develop this estimate is from the following references: (a) Todd L. Petersen, Petersen Aviation, Inc, *Aviation Oil Lead Content Analysis*, Report # EPA 1-2008, January 2, 2008, available at William J. Hughes Technical Center Technical Reference and Research Library at http://actlibrary.tc.faa.gov/ and (b) E-mail from Theo Rindlisbacher of Switzerland Federal Office of Civil Aviation to Bryan Manning of U.S. EPA, regarding lead retained in engine, September 28, 2007.

[57] This equation for piston-engine LTOs only applies to non-heliport facilities. See the text immediately below for equations for calculating piston-engine LTOs and Pb emissions at heliports.

[58] This was done using the following 4 engine types in EDMS 5.1: Robinson R22 IO-320-D1AD; Robinson R22 IO-360-B; Robinson R22 O-320; Robinson R22 TSIO-360C. The fuel consumption rates were: Robinson R22 IO-320-D1AD – 5.546 g Pb/LTO; Robinson R22 IO-360-B – 5.973 g Pb/LTO; Robinson R22 O-320 – 6.276 g Pb/LTO; Robinson R22 TSIO-360C – 8.604 g Pb/LTO.

not contain lead).[59] The 2008 FAA GAATA Survey reports that approximately 2% of all AT helicopter hours flown are by piston-engine aircraft which use avgas, and about 98% are by turbine-engine powered rotocraft. We expect the fraction of helicopter activity conducted by piston-engines to vary by heliport with some facilities having no piston-engine powered helicopter activity and some hosting mainly or only piston-engine powered helicopters. However, in the absence of heliport-specific data, the national default estimates of 36% for GA and 2% for AT from the GAATA Survey were used. Therefore, to calculate piston-engine aircraft LTO as input for this equation, the helicopter GA LTOs were multiplied by 0.36 and helicopter AT LTOs were multiplied by 0.02.

Lead emitted at the heliport facility was calculated for the 2008 NEI using either the LTO data provided in FAA databases or the estimate LTO activity in the following equation (i.e., 141 LTOs):

$$\text{Pb(tons)} = \frac{\text{(piston-engine helicopter LTO) (6.60 g Pb/LTO) (0.95)}}{\text{907,180 g/ton}}$$

which simplifies to:

$$\text{Pb(tons)} = \text{(piston-engine helicopter LTO)} \; (6.9 \text{ X } 10^{-6})$$

Where piston-engine helicopter LTO = (Helicopter GA LTO x 0.36) + (Helicopter AT LTO x 0.02)

Section 7. Improving Airport-specific Lead Emissions Estimates

There are refinements to the methods described here that would improve airport-specific inventories, most of which involve acquiring airport- and aircraft-specific input data. The following information describes data inputs that could be used to generate airport lead inventories tailored to specific airports or otherwise improve the estimates using currently available data. State and local authorities might have, or be able to collect, better information for some of these key data inputs.

State and local agencies might have access to airport-specific data that would improve the national estimates of lead emissions per LTO. These improvements largely involve replacing national average or default values with airport-specific data on the activity of piston-engine aircraft. Three key data inputs are:

[59] The FAA GAATA is a database collected from surveys of pilots flying aircraft used for general aviation and air taxi activity. For more information on the GAATA, see Appendix A at http://www.faa.gov/data_statistics/aviation_data_statistics/general_aviation/

1) Airport-specific LTO activity for piston-powered aircraft, including the fraction of piston-engine activity conducted by single- versus twin-engine aircraft. Some airport facilities collect this information and states may use these data to calculate airport-specific lead inventories. The activity data should be current and updated on a regular schedule so that the data represents the inventory year as closely as possible.
2) The time spent in each mode of the LTO cycle. EPA uses the EDMS scenario property of ICAO/USEPA Default - Times in Mode, with a 16 minute taxi-in/taxi-out time according to EPA's Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources, 1992. While some local authorities have confirmed that these are the relevant times in mode at their airports for piston aircraft, the applicability of these times in mode will vary by airport. EPA has learned that one of the important factors in piston aircraft operation that is currently not included in the time in mode or emissions estimates is the time and fuel consumption during the pre-flight run-up checks conducted by piston-engine aircraft prior to takeoff.
3) Other data inputs for the airport-specific lead inventory calculation for which states or local authorities may provide airport-specific information include the concentration of lead in the avgas supplied at an airport, and the fraction of lead in fuel that is retained in the engine and oil, and aircraft-specific fuel consumption rates by the piston-engine aircraft in specific modes of operation.

The accuracy of the based aircraft data on which equation 4 is modeled can be improved. FAA recognizes the need to improve the integrity of the 5010 data report based-aircraft counts for all of the GA airports and reliever airports in the NPIAS and is currently in the process of improving the data collection and submission methods to accomplish this task.[60]

Section 8. Lead emitted in flight (i.e., outside the LTO cycle):

Lead emissions, especially those at altitude, undergo dispersion and eventually deposit to surfaces, and lead deposited to soil and water can remain available for uptake by plants, animals and humans for long periods of time. Because lead is a persistent pollutant, we are including all lead emissions – at airports and in-flight – in the NEI.[61]

For inventory purposes, lead emitted outside the LTO cycle occurs during aircraft cruise mode and portions of the climb-out and approach modes above the mixing height (typically 3,000 ft[62]). This part of an aircraft operation emits lead at various altitudes as well as close to and away from airports. Because the precise area of lead emission and deposition is not known for these flights, EPA is using a simplistic approach to allocate

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[60] National Based Aircraft Inventory Program: http://www.basedaircraft.com/public/FrequentlyAskedQuestions.aspx, accessed 2/17/2009

[61] U.S. EPA, 2006. Air Quality: Criteria for Lead: 2006; EPA/600/R-5/144aF; U.S. Government Printing Office, Washington, DC, October, 2006.

[62] According to EPA's *Procedurees for Emission Inventory Preparation, Volume IV: Mobile Sources, 1992.*

these emissions for the purposes of the 2008 NEI. A brief explanation of the nature of GA flights is provided here for context regarding emissions of lead in-flight.

FAA categorizes GA flights as either local area or itinerant operations and this distinction plays a role in the area over which lead is emitted. Local operations are those activities performed by aircraft operating in the local traffic pattern or within sight of the airport, aircraft executing simulated instrument approaches or low passes at the airport, and/or aircraft operating to or from the airport in a designated practice area located within a 20-mile radius of the airport. Local operations are common for GA aircraft. This includes applications such as recreational, proficiency and instructional flying as well as many common general aerial support tasks. Emissions during local flying are more likely to influence air and soil concentrations of lead in the vicinity of the airport because they occur near the airport, often at altitudes below the mixing height.

Itinerant operations are all operations other than those described above as local operations. An itinerant aircraft operation usually is one in which the aircraft departs from one airport and lands at a different airport. Depending on air time and distance, an itinerant flight is much more likely to involve departing the local flying area of the originating airport and climbing to altitudes above the mixing height. It is reasonable then, to generally expect that lead emitted outside the LTO cycle during itinerant operations, in contrast with local operations, will be more widely dispersed and at greater distances from the airport.

The portion of the national avgas lead emitted in flight (i.e., outside the LTO cycle) is calculated by subtracting the sum of airport facility lead inventories from the national avgas lead inventory. Even though FAA collects and reports information regarding the fraction of GA operations that are local and itinerant, there is no practical method to assign in-flight lead emissions to small geographic areas such as airports or census tracts. And similar data is not available for AT operations, a portion of which are conducted by piston-engine aircraft. Since the average duration of a piston-engine aircraft flight is approximately an hour, an itinerant flight can traverse county lines. Therefore, given the current data available, the best approach is to assign the out-of-LTO cycle lead to the state where the flight originated.

In the 2008 NEI EPA allocated lead emissions that are calculated as being outside the LTO cycle to states based on the state-specific fraction of national GA and AT piston-engine LTO activity. The state-specific fractions were calculated by multiplying the percent of GA and AT piston-engine LTO activity in each state by 296 tons, which is the amount of lead we currently estimate is emitted outside of the LTO cycle nationwide. Table 4 presents the total GA and AT piston-engine LTOs by state, the state-specific faction of national GA and AT piston-engine LTO activity, and the out-of-LTO lead emissions assigned to each state.

Table 4: Out-of-LTO Lead Emissions by State

STATE	Total GA and AT Piston LTOs	Percent of National GA and AT Piston LTOs (by state)	Out of LTO Pb emissions (tons)
AK	660,133	2.0%	5.86
AL	671,026	2.0%	5.96
AR	638,875	1.9%	5.68
AZ	1,430,302	4.3%	12.71
CA	3,881,357	11.6%	34.48
CO	780,426	2.3%	6.93
CT	226,807	0.7%	2.01
DC	28,833	0.1%	0.26
DE	84,617	0.3%	0.75
FL	2,751,015	8.3%	24.44
GA	750,876	2.3%	6.67
HI	138,432	0.4%	1.23
IA	281,961	0.8%	2.50
ID	430,812	1.3%	3.83
IL	920,908	2.8%	8.18
IN	566,583	1.7%	5.03
KS	459,720	1.4%	4.08
KY	280,378	0.8%	2.49
LA	622,011	1.9%	5.53
MA	714,159	2.1%	6.34
MD	436,861	1.3%	3.88
ME	228,302	0.7%	2.03
MI	880,818	2.6%	7.82
MN	647,876	1.9%	5.76
MO	389,551	1.2%	3.46
MS	461,383	1.4%	4.10
MT	270,311	0.8%	2.40
NC	743,004	2.2%	6.60
ND	214,139	0.6%	1.90
NE	221,681	0.7%	1.97
NH	173,355	0.5%	1.54
NJ	466,961	1.4%	4.15
NM	309,657	0.9%	2.75
NV	298,712	0.9%	2.65
NY	999,738	3.0%	8.88
OH	1,180,583	3.5%	10.49
OK	575,402	1.7%	5.11
OR	596,730	1.8%	5.30
PA	954,839	2.9%	8.48

PR	80,728	0.2%	0.72
RI	45,348	0.1%	0.40
SC	506,650	1.5%	4.50
SD	228,198	0.7%	2.03
TN	535,913	1.6%	4.76
TX	2,422,722	7.3%	21.52
UT	299,471	0.9%	2.66
VA	502,559	1.5%	4.46
VI	25,763	0.1%	0.23
VT	88,318	0.3%	0.78
WA	1,189,142	3.6%	10.56
WI	778,320	2.3%	6.91
WV	143,393	0.4%	1.27
WY	106,190	0.3%	0.94

For additional information or if you have questions regarding the methods described in this document, please contact Meredith Pedde (pedde.meredith@epa.gov) or Marion Hoyer (hoyer.marion@epa.gov).

Supplemental Table 1

Table A-1: Scaling factors

Year	U.S. Product Supplied of Aviation Gasoline (Thousand Barrels)[63]	Ratio of 2008 to Year X
Before 1981[64]		0.57
1981	11,147	0.50
1982	9,307	0.60
1983	9,444	0.59
1984	8,692	0.64
1985	9,969	0.56
1986	11,673	0.48
1987	9,041	0.62
1988	9,705	0.58
1989	9,427	0.59
1990	8,910	0.63
1991	8,265	0.68
1992	8,133	0.69
1993	7,606	0.74
1994	7,555	0.74
1995	7,841	0.71
1996	7,400	0.76
1997	7,864	0.71
1998	7,032	0.80
1999	7,760	0.72
2000	7,188	0.78
2001	6,921	0.81
2002	6,682	0.84
2003	5,987	0.94
2004	6,189	0.91
2005	7,006	0.80
2006	6,626	0.85
2007	6,258	0.90
2008	5,603	1.00

[63] Data from the Energy Information Administration's (EIA's) table, "U.S. Product Supplied of Aviation Gasoline (Thousand Barrels)." Available at: http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=mgaupus1&f=A Accessed August 25, 2010.

[64] EIA does not have data for volumes of avgas product supplied for years earlier than 1981. To calculate the scaling factor to use for activity data from years before 1981, we used the ratio of 2008 avgas volume product supplied to the average avgas volume supplied from 1981 to 1989.

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Documentation for the Commercial Marine Vessel Component of the National Emissions Inventory

Methodology

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1.0 INTRODUCTION

1.1 What is the National Emission Inventory?

The National Emission Inventory (NEI) is a comprehensive inventory covering all anthropogenic sources of criteria pollutants and hazardous air pollutants (HAPs) for all areas of the United States. The NEI was created by the U.S. Environmental Protection Agency's Emission Inventory and Analysis Group (EIAG) in Research Triangle Park, North Carolina. The NEI will be used to support air quality modeling and other activities. To this end, the EPA established a goal to compile comprehensive emissions data in the NEI for criteria and HAPs for mobile, point, and nonpoint sources. This report presents an overview of how emission estimates for the commercial marine vessel (CMV) component of the 2008 NEI was compiled.

1.2 Why Did the EPA Create the NEI?

The Clean Air Act (CAA), as amended in 1990, includes mandates for the EPA related to criteria and hazardous air pollutants. The CAA defines criteria pollutants as being one of the following air pollutants:

- Carbon monoxide (CO);
- Sulfur oxides (SO_x);
- Nitrogen oxides (NO_x);
- Ozone; and
- Particulate matter (PM).

Where emission factors and activity data permit, ammonia (NH_3) estimates are also included as an important precursor to PM. Hazardous air pollutants are also delineated in the CAA, see *http://www.epa.gov/ttn/atw/188polls.html* for a complete list of regulated pollutants and their chemical abstract service [CAS] numbers.

The CAA requires the EPA to identify emission sources of these pollutants, quantify emissions, develop regulations for the identified source categories, and assess the public health and environmental impacts after the regulations are put into effect. The NEI is a tool that EPA can use to meet the CAA mandates. In this report, criteria and HAP emission estimates are discussed for CMV sources.

1.3 How is the EPA Going to Use This Version of the NEI?

It is anticipated that the emission inventory developed from this effort will have multiple end uses. The data have been formatted according to protocols established for the EPA's NEI submittals. The common data structure on which the NEI platform is based will allow the NEI emission data to be transferred to multiple end-users for a variety of purposes.

The criteria and HAP emission estimates developed for the NEI will be used to evaluate air pollution trends, air quality modeling analysis and impacts of potential regulations.

1.4 Report Organization

Following this introduction, Section 2.0 provides information on how the national CMV, emission estimates were developed. This inventory effort was coordinated by the EPA's Office of Transportation and Air Quality (OTAQ) and EIAG.

The appendix were created to provide technical details on how the national emissions were developed and how state and local inventory data (when provided) were incorporated into the national estimates. Appendix A provides a copy of the report documenting how the 2002 data were adjusted to reflect marine vessel activity and emissions for 2008.

2.0 DEVELOPMENT OF THE COMMERCIAL MARINE VESSEL COMPONENT FOR THE NEI

2.1 How Does This CMV Study Fit into the NEI?

The NEI was developed to include all point, nonpoint (sometimes referenced as “area”), and mobile sources. The approaches used in the point and nonpoint source categories are documented in other reports. Table 1 summarizes the approaches used to estimate emissions from all nonroad sources included in the NEI program. Those source categories and years that are included in this report are noted in bold.

The scope of this inventory component of the NEI was to compile criteria and HAP emissions data for CMVs operating in United States waters and federal waters extending 200 nautical miles from the United States’ coastline. In this effort, national emission estimates were often developed and allocated to counties based on available Geographic Information System (GIS) data. The methodologies used to estimate emissions and the procedures used to spatially allocate them to the county-level are discussed in this report.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
NONROAD Categories			
Nonroad Gasoline, Diesel, LPG, CNG	2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA’s National Mobile Inventory Model (NMIM), which incorporates NONROAD2004. Where states provided alternate nonroad inputs, these data replaced EPA default inputs. State-supplied emissions data also replaced default EPA emission estimates.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
	1999	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) an updated 1999 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. Replaced State-submitted data for California for all NONROAD model categories; Pennsylvania for recreational marine and aircraft ground support equipment, and Texas for select equipment categories.
	1996, 1997, 1998, 2000 & 2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated year-specific national and California inventories, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios and California county-to-state ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. California results replace the diesel equipment emissions generated from prior application of county-to-national ratios.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1990 and 1996 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1990 and 1996. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1990 county-level emissions to estimate 1991-1995 emissions.
	1990	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1990 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1986, 1988, & 1989	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1985 and 1990 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1985 and 1990. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1985 county-level emissions to estimate 1986-1989 emissions.
	1987	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for 1987 by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1985	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1985 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1970, 1975, 1978, & 1980	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for all years by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.
	1996, 1997, 1998, 1999, 2000, & 2001	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD. NH_3 emissions for California were also recalculated using updated diesel fuel consumption values generated for California-specific runs, and assuming the 1996 county-level distribution.
	1985 & 1990	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD.
	1987	NH_3	Obtaining 1987 national fuel consumption estimates from Lockdown C NONROAD model and multiplying by NH_3 emission factors.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1970, 1975, 1978, & 1980	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1990, 1996, & 1999	HAPs	Speciation profiles applied to county VOC and PM estimates. Metal HAPs were calculated using fuel and activity-based emission factors. Some state data were provided and replaced national estimates. (2003)
Aircraft			
Commercial Aircraft	2008	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)
	2002	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) was run for criteria pollutants, VOC and PM emissions were speciated into HAP components. (2004)
	1990, 1996, 1999, 2000, 2001	VOC, NO_x, CO, SO_x	Input landing and take-off (LTO) data into FAA EDMS. National emissions were assigned to airports based on airport specific LTO data and BTS GIS data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2003)
General Aviation, Air Taxis	2008	Criteria and HAPs	Used FAA LTO data from TAF and OTAQ provided activity data for smaller airports derived from FAA 5010 master plans. EPA approved generic emission factors for criteria estimates. Speciation profiles were applied to VOC and PM estimates to get national HAP estimates. (2009)

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
General Aviation, Air Taxis (Continued)	1978, 1987, 1990, 1996, 1999, 2000, 2001, & 2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to develop national HAP estimates. (2004)
	1990, 1996, 1999, & 2002	Pb	Used Department of Energy (DOE) aviation gasoline usage data with lead concentration of aviation gasoline. (2004)
	1996	NH_3	Applied NH_3 emissions factors to 1996 national jet fuel and aviation gasoline consumption estimates.
Military Aircraft	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, 2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed. (2009)
	1970-1998	VOC, NO_x, CO, SO_X, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
Auxiliary Power Units	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)
	1985-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using LTO operations data from the FAA. Estimation methods prior to 1996 reported in EPA, 1998.

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Unpaved Airstrips[1]	1985-2001	PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Aircraft Refueling[1]	1985-2001	VOC	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Commercial Marine Vessel (CMV)			
All CMV Categories	**2008**	**VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$**	**2002 estimates were adjusted by OTAQ to reflect 2008 activity levels., note that the SCCs for this category have changed such that the Diesel category refers to smaller vessels (Category 1 and 2) using distillate fuels and the Residual category refers to larger (Category 3) vessel using a blend of residual fuels (2009)**
	2008	**HAPs**	**OTAQ's 2008 estimates were speciated into HAP components using SEPA profiles**
	2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2001 Estimates carried over. Used state data when provided. (2004)
		HAPs	1999 Estimates carried over. Used state data when provided. (2004)
CMV Diesel	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Used criteria emission estimates in the background document for marine diesel regulations for 2000. Adjusted 2000 criteria emission estimates for other used based on fuel usage. Emissions were disaggregated into port traffic and underway activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
	1996	NH_3	Applied NH_3 emissions factors to 1996 distillate and residual fuel oil estimates (i.e., as reported in EIA, 1996).
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.
CMV Steam Powered	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Calculated criteria emissions based on EPA SIP guidance. Emissions were disaggregated into port traffic and under way activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, & 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
Military Marine	1997-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CMV Coal,[2] CMV, Steam powered, CMV Gasoline[2]	1997-1998	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CM Coal, CMV, Steam powered, CMV Gasoline, Military Marine	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Estimation methods reported in EPA, 1998.
Locomotives			
Class I, Class II, Commuter, Passenger, and Yard Locomotives	1978, 1987, 1990, 1996, 1999, 2000, 2000, & 2002	VOC, NO_x, CO, PM_{10}, $PM_{2.5}$	Criteria pollutants were estimated by using locomotive fuel use data from DOE EIA and available emission factors. County-level estimates were obtained by scaling the national estimates with the rail GIS data from DOT. State data replaced national estimates. (2004)

Table 2-1. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Class I, Class II, Commuter, Passenger, and Yard Locomotives (Continued)	1978, 1987, 1990, 1996, 1999, 2000, 2001, & 2002	SO_2	SO_x emissions were calculated by using locomotive fuel use and fuel sulfur concentration data from EIA. County-level estimates were obtained by scaling the national estimates with the county level rail activity data from DOT. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. County-level estimates were obtained by scaling the national estimates with the county level rail activity from DOT. State data replaced national estimates. (2004)
	1997-1998	NH_3	Grew 1996 base year emissions using EGAS growth indicators.
	1996	NH_3	Applied NH_3 emissions factors to diesel consumption estimates for 1996.
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Notes:
* Dates included at the end of Estimation Method represent the year that the section was revised.
1 Emission estimates for unpaved airstrips and aircraft refueling are included in the area source NEI, since they represent non-engine emissions.
2 National Emission estimates for CMV Coal and CMV Gasoline were not developed though states and local agencies may have submitted estimates for these source categories.
EPA, 1998. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Factors and Inventory Group, National Air Pollutant Emission Trends, Procedures Document, 1900–1996, EPA-454/R-98-008. May 1998.

The target inventory area includes every state in the United States and every county within a state. There are no boundary limitations pertaining to traditional criteria pollutant nonattainment areas or to designated urban areas. The pollutants inventoried included all criteria pollutants (except for the other nonroad source category which addressed only HAPs in this report) and the 188 HAPs identified in Section 112(b) of the CAA. Some state or local agencies provided emissions information on more HAPs than those delineated in the CAA, only the federally regulated HAPs are included in the NEI.

In addition to numerous specific chemical compounds, the list of 188 HAPs includes several compound groups [e.g., individual metals and their compounds, polycyclic organic matter (POM)]; the NEI includes emission estimates for the individual compounds wherever possible. Many of the uses of the NEI depend upon data (e.g., toxicity) for individual compounds within these groups rather than aggregated data on each group as a whole.

The intent in presenting the following emission inventory approach is to provide sufficient and transparent documentation such that states and local agencies can use these approaches, in conjunction with their specific local activity data to develop more accurate and comparable emission estimates in future submittals.

2.2 What are Commercial Marine Vessels?

The CMV source category includes all boats and ships used either directly or indirectly in the conduct of commerce or military activity. These vessels range from 20-foot charter boats to large tankers which can exceed 1,000 feet in length (EPA, 1989). In spite of the broad range of vessels represented by this category, a number of common characteristics allow for the use of simple emission estimation methods. 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 it is assumed that Category 3 vessels primarily use residual blends while Category 1 and 2 vessels typically used distillate fuels.

The Category 3 (C3) inventory developed by OTAQ includes vessels which use C3 engines for propulsion. C3 engines are defined as having displacement above 30 liters per cylinder (U.S. EPA, 2003). 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. baseline, which is roughly equivalent to the border of the U.S. Exclusive Economic Zone (EEZ).

Category 1 and 2 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 Category 1 and 2 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 engines (EPA, 1989). Emissions from recreational marine vessels are included in the nonroad source category.

2.3 What Pollutants are Included in the National Emission Estimates for CMVs?

The EPA's Office of Transportation and Air Quality (OTAQ) provided estimates for all criteria pollutants including volatile organic compounds (VOC), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$) and carbon dioxide (CO_2). Criteria emissions were provided for Category 1 and 2 vessels (Carey, 2009b); Category 3 port, reduced speed zone, and cruising activities (Carey, 2009a and Carey, 2009c); and Category 3 interport activities (Carey, 2009d).

The VOC and PM estimates were speciated into hazardous air pollutants (HAP) components based on available data sources. The Swedish Environmental Protection Agency (SEPA) document *Methodology for Calculating Emissions from Ships: 1. Update of emission factors* served as the primary source of HAP emission factors which were converted into speciation profiles (Cooper and Gustafsson, 2004). Ammonia emission factors were also obtained from the SEPA, but as these factors require activity data, and such data were not available for Category 3 vessels operating in Federal waters, ammonia was estimated as a ratio of PM_{10} using the SEPA emission factors. Similar ratios were developed for Category 1 and 2 vessels, assuming that this fleet primarily operates on marine diesel fuel with 80.5 percent of the fleet equipped with medium speed engines and the remaining 19.5 percent were high speed engines. This provided a weighted NH_3 emission factor of 4.61E-03 g/kw-hr for operations at-sea and in-port. The PM_{10} factors vary for at-sea (0.2 g/kw-hr) and in-port (0.4 g/kw-hr), so our NH_3 / PM_{10} ratios were different for at-sea (2.31E-02) and in-port (1.15E-02).

While the SEPA document was used as the primary speciation source, other resources were investigated for potential inclusion in this effort. Recent BTEX data from Moldanova et al. were examined, but it included inconsistent benzene factors, some over 20% of hydrocarbon (HC) factors, were much higher than others found in recent publications and, as a result, were not included (Cook, 2009). CE-CERT metals data was also reviewed as it pertained to slow speed residual fuel engines (Cook, 2009). The CE-CERT emission factors were in line with the Swedish factors for nickel and lead, but they were an order of magnitude different for chromium, cadmium, and selenium. As a result, the Swedish factors were retained over the CE-CERT data based on the larger study sample size, while CE-CERT's manganese emission factors were added as these factors were not included in the Swedish study (Cook, 2009).

The complete pollutant list for CMVs is shown in Table 2-2.

2.4 How Were the CMV Emissions Estimated?

As noted above, the CMV criteria and CO_2 emission estimates were provided for this inventory by OTAQ. Category 3 commercial marine inventories were developed for a base year of 2002 then projected to 2008 applying regional adjustment factors to account for growth. In addition, NO_X adjustment factors were applied to account for implementation of the NO_X Tier 1 standard. Details about adjustments and growth factors can be found in the Category 3 documentation (Appendix A). For Category 1 and 2 marine diesel engines, the emission estimates were consistent with the 2008 Locomotive and Marine federal rule making (Carey, 2009b).

Table 2-2. Commercial Marine Vessel Pollutant List

2,2,4 Trimethylpentane	Carbon Monoxide*	Naphthalene
Acenaphthene	Chromium(VI)	Nickel
Acenaphthylene	Chromium (III)	Nitrogen Oxides*
Acetaldehyde	Chrysene	PAH, total
Acrolein	Cobalt	Phenanthrene
Ammonia	Dibenzo[a,h]Anthracene	Phosphorus
Anthracene	Dioxins/Furans	PM10 Primary*
Arsenic	Ethyl benzene	PM2.5 Primary+
Benz(a)anthracene	Fluoranthene	Polychlorinated Biphenyls
Benzene	Fluorene	Propionaldehyde
Benzo(a)pyrene	Formaldehyde	Pyrene
Benzo(b)fluoranthene	Hexachlorobenzene	Selenium
Benzo(g,h,i)perylene	Hexane	Styrene
Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene	Sulfur Dioxide*
Beryllium	Lead	Toluene
Cadmium	Manganese	VOCs*
Carbon Dioxide*	Mercury	Xylene

* Provided by OTAQ

\+ $PM_{2.5}$ was provided by OTAQ for all vessels and modes except for Category 3 Interport, where it was calculated using OTAQ guidance.

OTAQ's emissions were then allocated to individual GIS polygons using appropriate methods that varied by operating mode (i.e., hotelling, maneuvering, reduced speed zone, and underway). HAP emissions were estimated by applying speciation profiles to each polygon's VOC and PM estimates. Figure 2-1 provides an overview of the approach used to estimate and spatially allocate CMV emissions.

Speciation profiles were applied to the VOC, PM_{10}, and $PM_{2.5}$ emission estimates to calculate the associated HAP emissions using the following equation.

$$VOC\text{-}PM_{10/2.5} * speciation\ profile_i = HAP\ emission\ estimate:$$

Where:

HAP emission estimate	= HAP Emission estimate (tons/year) for pollutant:
$VOC\text{-}PM_{10/2.5}$	= VOC or PM emission estimate (tons/year)
Speciation $Profile_i$	= VOC or PM speciation fraction for HAP i

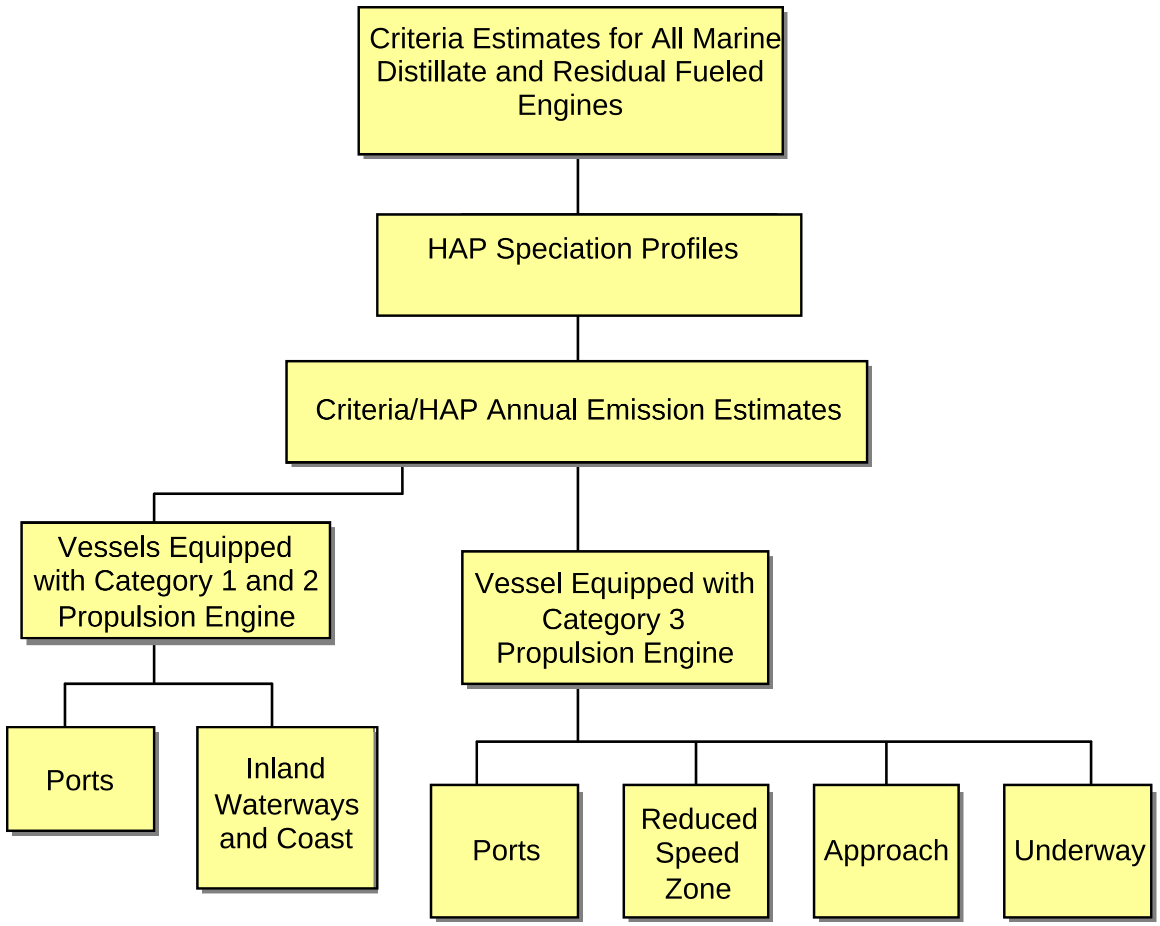

Figure 2-1. General Approach Used to Develop Marine Vessel Component of the 2008 National Emission Inventory

For Category I diesel-powered vessels, the speciation profiles were based on high-speed diesel vehicle (HSDV) factors obtained from information in the SEPA's *Methodology for Calculating Emissions from Ships: 1. Update of emission factors* (Cooper and Gustafsson, 2004). For Category 2 diesel-powered vessels, the speciation profiles were developed from medium-speed diesel vehicles (MSDV). Since emissions and activity data were provided as a combined value for all Category 1 and 2 vessels, the Category 1 and Category 2 emission factors were averaged to obtain a single emission factor for all diesel vessels. All port activities for Category 1 and 2 vessels were assumed to be maneuvering.

For Category 3 vessels, speciation profiles were developed using data from *Methodology for Calculating Emissions from Ships: 1. Update of emission factors* and assuming 80.5% of Category 3 vessels were equipped with slow-speed engines and 19.5% of vessels were equipped with medium speed engines based on vessel census data reported in the International Maritime Organization's (IMO) recent greenhouse gas (GHG) study (IMO 2009). Separate speciation profiles were created for Category 3 vessels for underway, maneuvering, and hotelling activities. Chromium emissions were split into hexavalent and trivalent chromium based on an assumption that 34% of total chromium was hexavalent and the remaining 66% was trivalent.

2.5 How Were Emissions Allocated?

Previous emissions allocations were based on waterway length and port county assignment. In this effort, spatial accuracy was greatly enhanced via the creation of GIS polygons representing port and waterway boundaries. GIS polygons allowed the estimation/allocation of emissions to defined port, waterway, and coastal areas, leading to improved spatial resolution compared to 2002's county-level emissions. Methodologies for both port and underway emissions are described in detail in the sections that follow.

2.6 How Were Port Emissions Allocated?

Port boundaries were developed using a variety of resources to identify the most accurate port boundaries. First, GIS data or maps provided directly from the port were used. Next, maps or port descriptions from local port authorities, port districts, etc. 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. Emphasis was placed on mapping the 117 ports with Category 3 vessel activity using available shape files of the port area. The Port of Huntington was developed differently given its large extent and limited available map data. The state of West Virginia provided a revised file of US Army Corps of Engineers *port terminals* reported to be part of the Port of Huntington-Tristate area. A 200 meter buffer of the water features near these port terminals was created to identify port area.

In all cases, polygons were created on land, bordering waterways and coastal areas, and were split by county boundary. Each polygon was identified by the port name and state and county FIPS in addition to a unique ShapeID. Smaller ports with Category 1 and 2 activities were mapped as small circles. Note that no Category 3 emissions were mapped to small circles. The final shapefile contained 159 ports and 196 polygons.

OTAQ provided Category 1 and 2 criteria emissions and activity as a single national number. These emissions and activity were allocated to ports based on total commodity tonnage data obtained from the U.S. Army Corps of Engineers (USACE) Principal Ports file for 2007 (U.S. ACE, 2009). Emissions were then assigned to polygons within a port based on port area.

OTAQ developed port-level emissions for 117 of the largest U.S. ports with Category 3 activity. Activity in megawatt hours (MWh) and resulting criteria and CO_2 emissions were provided by port for maneuvering and hotelling modes. Emissions were then assigned to polygons within a port based on port area. HAP emissions were then speciated from VOC and PM estimates for each polygon using the methodology described in Section 3.0.

2.7 How Were Underway Emissions Allocated?

For this inventory, a GIS polygon layer was created to more accurately represent the location of CMV-related activity and emissions. Inland waterway polygons were obtained from the Bureau of Transportation Statistics' National Transportation Atlas Database hydro polygon layer (U.S. DOT, 2007). These polygons were further divided by county boundary and waterway ID. Coastal waters were drawn using Mineral Management Service state-federal boundary files and were also divided to indicate county boundaries. Federal waters were included as large area blocks outlined by the Exclusive Economic Zone (EEZ) boundary provided by EPA, which extends to approximately 200 nautical miles from the coastline. The final product is a polygon layer that includes all inland and coastal state waters and federal waters along with FIP, polygon area, and a unique ShapeID. Underway emissions were allocated differently by vessel category and mode, as outlined below.

2.7.1 *Category 1 and 2 Underway*

OTAQ provided Category 1 and 2 criteria emissions and activity as a single national number. These emissions and activity were allocated to underway polygons in state waters based on total commodity movements (in tons) data obtained from USACE (U.S. ACE, 2001). These data were waterway-specific, so waterways that crossed into multiple FIPs had emissions assigned by waterway length in each polygon. HAP emissions were then speciated from VOC and PM estimates using the methodology described in Section 3.0 for each polygon.

2.7.2 *Category 3 Reduced Speed Zones (RSZ)*

OTAQ provided polyline shapefiles indicating location of RSZ activities along with port-specific RSZ emissions and activity. These polylines were intersected with existing shipping lane polygons, and emissions were allocated to polygons based on the approach segment length on a per-port basis. HAP emissions were then speciated from VOC and PM estimates using the methodology described in Section 3.0 for each polygon.

2.7.3 *Category 3 Approach*

OTAQ provided polyline shapefiles indicating location of cruising activities along with port-specific cruising emissions and activity. These polylines were intersected with our existing polygons, and emissions were allocated to polygons based on the approach segment length on a per-port basis. HAP emissions were then speciated from VOC and PM estimates using the methodology described in Section 3.0 for each polygon.

2.7.4 *Category 3 Interport*

OTAQ provided 4km grids for interport-only emissions for CO, CO_2, HC, NO_x, SO_x, and PM_{10}. These grids were provided in a customized projection which, without a custom geographic transformation, could not be converted to match the polygon layer's projection. Furthermore, the emission estimates provided by OTAQ were developed using EEZs which were in the GCS Arc Sphere projection. Per OTAQ's direction, the interport polygons were converted from North American Equidistant Conic to GCS Arc Sphere by using the data frame projections tool as the a transformation method. This approach was recommended by OTAQ in order to mirror previous methodology and provide emission estimates consistent with the recent Category 3 Commercial Marine Inventory. Zonal statistics tools were used to sum the gridded emissions within each underway polygon**.** HAP emissions were then speciated from VOC and PM estimates using the methodology described in Section 3.0 for each polygon.

2.8 QA/QC

Given the significant methodological changes over previous inventory efforts, several quality checks were implemented to ensure that these data were developed and allocated in a clear and reproducible manner. Some of the quality checks implemented include the following:

GIS shapefiles

- Topology was created and validated through several rounds or revisions to remove gaps or overlapping features both within and between polygon layers.
- Boundaries derived from Google Earth imagery were validated against Street Map network, port-provided map images, USACE ports points, and other online mapping resources to improve boundary accuracy.
- All final shapefiles and polygon characteristics (such as area, etc.) were managed and evaluated in a single projection to ensure quality area and distance measurements, consistent results across CMV activity types, and maximum accuracy across the study area. The only exception to this was in the case of the interport criteria emissions, as described in Section 4.2.4.

Emissions allocations and estimations

- Emission factors were compiled from a variety of sources, and emission factor development methodologies evaluated to identify the most accurate emission factor for use in this inventory effort.
- National emission sums were checked both before and after allocation to ensure no emissions were dropped or grown.
- HAP speciation profiles were checked for accuracy, and speciated emissions were checked on both the polygon and national level to ensure accuracy.
- All unit conversions were double-checked for errors.
- Emission sums were evaluated across activity types (i.e., hotelling, maneuvering, cruising, reduced speed zones, and interport) to ensure they consistently mirror activity levels.
- Port and underway emissions were examined across SCCs to ensure consistency with activity levels and vessel populations.

- 2008 pollutants and emissions were checked against the 2005 inventory to identify any missing pollutants or major changes compared to previous inventories. Discrepancies were investigated and revisions were made as needed.

2.9 What are the Results?

Table 2-3 summarizes the emission estimates for CMVs for criteria pollutants. Table 2-4 summarizes the emission estimates for individual HAPs. Note that for the purposes of this inventory vessels equipped with category 1 and 2 propulsion engines are assumed to operate on Distillate diesel, while vessels equipped with Category 3 propulsion engines are assumed to used a residual blend. Both tables provide data for all states; these 2008 estimates do not include state submitted data.

Table 2-3. Commercial Marine Vessel Criteria and Greenhouse Gas Emission Estimates 2008 (TPY)

Pollutant	Diesel Port	Diesel Underway	Diesel Total	Residual Port	Residual Underway	Residual Total	CMV Total
CO	113,452	37,817	151,269	5,871	68,588	74,459	**225,728**
CO_2	39,221,848	13,073,950	52,295,798	3,703,169	30,986,332	34,689,501	**86,985,299**
NH_3	210	140	350	64	323	387	**737**
NO_X	588,844	196,281	785,125	70,044	813,908	883,952	**1,669,077**
PM10-PRI	20,954	6,985	27,939	6,730	67,702	74,432	**102,371**
PM25-PRI	20,325	6,775	27,100	6,081	62,318	68,399	**95,499**
SO_2	34,803	11,601	46,404	52,512	522,327	574,839	**621,243**
VOC	12,752	4,251	17,003	2,412	28,711	31,123	**48,126**

* Note that for the purposes of this inventory vessels equipped with category 1 and 2 propulsion engines are assumed to operate on Distillate diesel, while vessels equipped with Category 3 propulsion engines are assumed to used a residual blend.

Table 2-4. Commercial Marine Vessel HAP Emission Estimates 2008 (TPY)

Pollutant	Diesel Port	Residual Port	Diesel Underway	Residual Underway
2,2,4-Trimethylpentane	3.825675	NA	1.062688	NA
Acenaphthene	0.36585	0.002068	0.101625	0.021188
Acenaphthylene	0.564019	0.003193	0.156672	0.032717
Acetaldehyde	710.6	0.552315	197.388896	6.574751
Acrolein	33.47466	NA	9.298516	NA
Anthracene	0.564019	0.003193	0.156672	0.032717
Arsenic	0.366686	2.358644	0.209535	11.836005
Benz[a]Anthracene	0.60975	0.003448	0.169375	0.035334
Benzene	194.5738	0.023636	54.048288	0.281365
Benzo[a]Pyrene	0.052384	0.011793	0.034923	0.059180
Benzo[b]Fluoranthene	0.104768	0.023586	0.069845	0.118360
Benzo[g,h,i,]Perylene	0.137194	0.000778	0.038109	0.007977
Benzo[k]Fluoranthene	0.052384	0.011793	0.034923	0.059180
Beryllium	NA	0.003674	NA	0.036965
Cadmium	0.059298	0.057506	0.035970	1.530064
Chromium (VI)	0.178105	1.224973	0.118737	4.419583
Chromium III	0.345733	2.377888	0.230489	8.579191
Chrysene	0.106706	0.000604	0.029641	0.006188
Cobalt	NA	1.717108	NA	10.426100
Dioxins/Furans as 2,3,7,8-TCDD TEQs	1.57E-06	1.18E-06	0.000001	0.000006
Ethyl Benzene	19.12838	NA	5.313438	NA
Fluoranthene	0.335363	0.001897	0.093156	0.019443
Fluorene	0.746944	0.004227	0.207484	0.043311
Formaldehyde	1430.802	3.786611	397.445137	45.075801
Hexachlorobenzene	0.000419	9.43E-05	0.000279	0.000473
Hexane	52.60303	NA	14.611954	NA
Indeno[1,2,3-c,d]Pyrene	0.104768	0.023586	0.069845	0.118360
Lead	1.571513	0.354705	1.047675	1.773791
Manganese	0.032059	0.385606	0.008905	3.879322
Mercury	0.000524	0.008218	0.000349	0.035508
Naphthalene	21.35649	0.121021	5.932360	1.240126
Nickel	10.47675	90.68502	6.984500	398.764466
PAH, total	26.5488	0.154501	7.496895	1.584859
Phenanthrene	0.85365	0.004829	0.237125	0.049480
Phosphorus		26.71489	NA	387.932155
Polychlorinated Biphenyls	0.005238	0.001179	0.003492	0.005918
Propionaldehyde	58.34154	NA	16.205985	NA
Pyrene	0.594506	0.003363	0.165141	0.034462
Selenium	0.000593	0.053465	0.000360	0.235603
Styrene	20.08479	NA	5.579110	NA
Toluene	30.6054	NA	8.501500	NA
Xylenes (Mixed Isomers)	45.9081	NA	12.752250	NA

* Note that for the purposes of this inventory vessels equipped with category 1 and 2 propulsion engines are assumed to operate on Distillate diesel, while vessels equipped with Category 3 propulsion engines are assumed to used a residual blend.
NA – Not Applicable.

2.10 Commercial Marine Vessel References

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Appendix A
2008 Category 3 Commercial Marine Vessel Inventory Methodology

Citation: U.S. Environmental Protection Agency. *Development of 2008CY Category 3 Commercial Marine Inventory*. Office of Transportation and Air Quality, Ann Arbor, MI. 2009.

Development of 2008CY Category 3 Commercial Marine Inventory

The Category 3 (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. baseline, which is roughly equivalent to the border of the U.S. Exclusive Economic Zone (EEZ). The U.S. region was clipped to the boundaries of the U.S. EEZ in areas where the 200nm boundary extended beyond the EEZ.

Category 3 commercial marine inventories were developed for a base year of 2002. [1] These were then projected to 2008. Regional adjustment factors were applied to account for growth. In addition, NO_X adjustment factors were applied to account for implementation of the NO_X Tier 1 standard. The methodology for each type of adjustment is described below.

Growth Factors by Geographic Region

The emissions inventory is calculated for nine geographic regions: Alaska East, Alaska West, East Coast, Gulf Coast, Hawaii East, Hawaii West, North Pacific, South Pacific, and the Great Lakes. Average annual growth rates from 2002-2020 were calculated for five regions: East Coast, Gulf Coast, North Pacific, South Pacific, and the Great Lakes. The Alaska regions were assigned the growth factor for the North Pacific region, while the Hawaii regions were assigned the growth factor for the South Pacific region. Each regional growth rate was then compounded over the inventory projection time period for 2008 (i.e., 6 years). The average annual growth rates and resulting multiplicative growth factors for each emission inventory region is presented in Table 1 below.

Table 1. Regional Emission Inventory Growth Factors for 2008

Emission Inventory Region	2002-2020 Average Annualized Growth Rate (%)	Multiplicative Growth Factor for 2008 Relative to 2002
Alaska East (AE)	3.3	1.2151
Alaska West (AW)	3.3	1.2151
East Coast (EC)	4.5	1.3023
Gulf Coast (GC)	2.9	1.1871
Hawaii East (HE)	5.0	1.3401
Hawaii West (HW)	5.0	1.3401
North Pacific (NP)	3.3	1.2151
South Pacific (SP)	5.0	1.3401
Great Lakes (GL)	1.7	1.1064

NO_X Adjustment Factors

The 2008 calendar year baseline inventory includes pre-control (Tier 0) engines and those subject to the NO_X Tier 1 standard that became effective in 2000. The NO_X emission factors (EFs) by tier and engine/ship type are given in Table 2.

Table 2. NO_X Emission Factors by Tier

Engine/Ship Type	**NO_X EF (g/kW-hr)**	
	Tier 0	**Tier 1**
Main		
Slow-Speed Diesel (SSD)	18.1	16.1
Medium-Speed Diesel (MSD)	14	12.5
Steam Turbine (ST)	2.1	n/a
Gas Turbine	6.1	n/a
Auxiliary		
Passenger Ship	14.6	13.0
Other Ships	14.5	12.9

The NO_X EFs by tier were then used with age distributions to generate calendar year NO_X EFs by engine/ship type for 2008. For 2002, Tier 0 EFs were used for simplicity. These calendar year NO_X EFs are provided in Table 3. Since the age distributions are different for vessels in the Great Lakes, NO_X EFs were determined separately for the Great Lakes.

Table 3. NO_X Emission Factors by Calendar Year

Engine/Ship Type	**CY NO_X EF (g/kW-hr)**		
		2008	
	2002	**DSP[a]**	**GL[b]**
Main			
Slow-Speed Diesel (SSD)	18.1	17.07	17.50
Medium-Speed Diesel (MSD)	14	13.01	13.74
Steam Turbine (ST)	2.1	2.1	2.1
Gas Turbine	6.1	6.1	n/a
Auxiliary			
Passenger Ship	14.6	13.76	14.32
Other Ships	14.5	13.60	14.16

[a]DSP = Deep sea ports and areas other than the Great Lakes
[b]GL = Great Lakes

Emission adjustment factors for NO_X were then calculated. Adjustment factors are ratios of the 2008 calendar year EFs to the 2002 calendar year EFs. The adjustment factors by engine/ship type are provided in Table 4.

Table 4. NO_X EF Adjustment Factors for 2008CY

Engine/Ship Type	2008 NO_X Adj (unitless)	
	DSP[a]	**GL[b]**
Main		
Slow-Speed Diesel (SSD)	0.9433	0.9670
Medium-Speed Diesel (MSD)	0.9293	0.9815
Steam Turbine (ST)	1.0000	1.0000
Gas Turbine	1.0000	n/a
Auxiliary		
Passenger Ship	0.9403	0.9784
Other Ships	0.9403	0.9784

<u>Methodology for Development of 2008CY Port Inventories</u>

For the non-California ports, 2002 emissions for each port are summed by engine/ship type. Propulsion and auxiliary emissions are summed separately, since the EF adjustment factors differ. The appropriate regional growth factor, as provided in Table 1, is then applied, along with the NO_X EF adjustment factors by engine/ship type in Table 4 to calculate the 2008 port inventories.

For the California ports, 2002 emissions for each port are summed by ship type. Propulsion and auxiliary emissions are summed separately, since the EF adjustment factors differ. The EF adjustment factors by engine/ship type in Table 4 are consolidated by ship type, using the CARB assumption that engines on all ships except passenger ships are 95 percent slow speed diesel (SSD) engines and 5 percent medium speed diesel engines (MSD) based upon a 2005 CARB survey. All passenger ships were assumed to be MSD engines. Steam turbines (ST) and gas turbines (GT) are not included in the CARB inventory. The NO_X EF adjustment factors by ship type are then applied, along with ship-specific growth factors used by CARB, to calculate the 2008 California port inventories. The ship-specific growth factors for 2008 relative to 2002 are provided in Table 5 below.

Table 5. Growth Factors by Ship Type for California Ports

Ship Type	Calendar Year	
	2002	2008
Auto	1.0000	1.1525
Bulk	1.0000	0.7412
Container	1.0000	1.4023
General	1.0000	0.9071
Passenger	1.0000	1.9823
Reefer	1.0000	1.0112
RoRo	1.0000	1.1525
Tanker	1.0000	1.3005

Methodology for Development of 2008CY Interport Inventories

The interport portion of the inventory is not segregated by engine or ship type. As a result, regional NO_X EF adjustment factors were developed based on the assumed mix of main (propulsion) engine types in each region. The mix of main engine types by region was developed using the ship call and power data and is presented in Table 6. Main engines are considered a good surrogate for interport emissions, since the majority of emissions while underway are due to the main engines. The NO_X EF adjustment factors by main engine type in Table 4 were used together with the mix of main engine types by region in Table 6 to develop the regional adjustment factors. The resulting NO_X EF regional adjustment factors are provided in Table 7. These NO_X EF regional adjustment factors, together with the regional growth factors in Table 1, were applied to calculate the 2008 interport inventories.

Table 6. Installed Power by Main Engine Type

Region	2008 Installed Power (%)			
	MSD	SSD	GT	ST
Alaska East (AE)	19.1%	18.4%	0.3%	62.2%
Alaska West (AW)	19.1%	18.4%	0.3%	62.2%
East Coast (EC)	25.6%	72.5%	0.9%	1.0%
Gulf Coast (GC)	13.7%	85.5%	0.0%	0.8%
Hawaii East (HE)	66.2%	18.5%	7.4%	8.0%
Hawaii West (HW)	66.2%	18.5%	7.4%	8.0%
North Pacific (NP)	5.1%	83.5%	1.6%	9.7%
South Pacific (SP)	17.8%	82.2%	0.0%	0.0%
Great Lakes (GL)	47.9%	43.7%	0.0%	8.4%

Table 7. NO_X EF Regional Adjustment Factors

Region	2002	2008
Alaska East (AE)	1.0000	0.9761
Alaska West (AW)	1.0000	0.9761
East Coast (EC)	1.0000	0.9408
Gulf Coast (GC)	1.0000	0.9419
Hawaii East (HE)	1.0000	0.9428
Hawaii West (HW)	1.0000	0.9428
North Pacific (NP)	1.0000	0.9490
South Pacific (SP)	1.0000	0.9408
Great Lakes (GL)	1.0000	0.9767

The resulting 2008 Category 3 emission inventories are shown in Table 8 for each of the nine geographic regions and the nation.

Table 8. 2008 Regional and National Emissions from Category 3 Vessel Main and Auxiliary Engines

Region	Metric Tonnes						
	NO_X	PM_{10}	$PM_{2.5}$ [a]	HC	CO	SO_2	CO_2
Alaska East (AE)	21,590	1,749	1,609	733	1,730	13,032	807,159
Alaska West (AW)	71,901	5,755	5,294	2,441	5,750	42,694	2,631,081
East Coast (EC)	271,707	23,021	21,180	9,573	22,665	190,767	10,696,360
Gulf Coast (GC)	195,240	16,839	15,492	6,903	16,990	125,728	7,604,870
Hawaii East (HE)	28,837	2,403	2,211	1,013	2,390	17,843	1,108,047
Hawaii West (HW)	40,573	3,381	3,110	1,426	3,362	25,105	1,559,016
North Pacific (NP)	30,248	2,647	2,435	1,153	2,568	18,790	1,216,723
South Pacific (SP)	132,669	10,982	10,103	4,692	11,368	81,896	5,145,632
Great Lakes (GL)	16,395	1,318	1,212	557	1,312	9,797	605,001
Total Metric Tonnes	**809,160**	**68,094**	**62,646**	**28,492**	**68,136**	**525,651**	**31,373,889**
Total Short Tons [b]	**891,946**	**75,061**	**69,056**	**31,407**	**75,107**	**579,431**	**34,583,792**

[a] Estimated from PM_{10} using a multiplicative adjustment factor of 0.92.

Reference (for 2002 inventory development)

1) U.S. Environmental Protection Agency, "Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Category 3 Marine Diesel Engines," Office of Transportation and Air Quality, EPA-420-D-09-002, June 2009.

Appendix B

2008 Commercial Marine Vessel Hazardous Air Pollutant Speciation Profiles

Table 1. Category 1 and 2 Hazardous Air Pollutant Speciation Profile for Port Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
540841	2,2,4-trimethylpentane	VOC	3.00E-04
83329	Acenaphthene	$PM_{2.5}$	1.80E-05
208968	Acenaphthylene	$PM_{2.5}$	2.78E-05
75070	Acetaldehyde	VOC	5.57E-02
107028	Acrolein	VOC	2.63E-03
NH3	Ammonia	PM_{10}	1.15E-02
120127	Anthracene	$PM_{2.5}$	2.78E-05
7440382	Arsenic	PM_{10}	1.75E-05
56553	Benz[a]Anthracene	$PM_{2.5}$	3.00E-05
71432	Benzene	VOC	1.53E-02
50328	Benzo[a]Pyrene	PM_{10}	2.50E-06
205992	Benzo[b]Fluoranthene	PM_{10}	5.00E-06
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	6.75E-06
207089	Benzo[k]Fluoranthene	PM_{10}	2.50E-06
7440439	Cadmium	PM_{10}	2.83E-06
16065831	Chromium III	PM_{10}	1.65E-05
18540299	Chromium VI	PM_{10}	8.50E-06
218019	Chrysene	$PM_{2.5}$	5.25E-06
600	Dioxin	PM_{10}	2.50E-09
100414	Ethylbenzene	VOC	1.50E-03
206440	Fluoranthene	$PM_{2.5}$	1.65E-05
86737	Fluorene	$PM_{2.5}$	3.68E-05
50000	Formaldehyde	VOC	1.12E-01
118741	Hexachlorobenzene	PM_{10}	2.00E-08
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	5.00E-06
439921	Lead	PM_{10}	7.50E-05
7439965	Manganese	PM_{10}	1.53E-06
7439976	Mercury	PM_{10}	2.50E-08
91203	Naphthalene	$PM_{2.5}$	1.05E-03
110543	n-Hexane	VOC	4.13E-03
7440020	Nickel	PM_{10}	5.00E-04
1336363	Polychlorinated Biphenyls	PM_{10}	2.50E-07
85018	Phenanthrene	$PM_{2.5}$	4.20E-05
123386	Propionaldehyde	VOC	4.58E-03
129000	Pyrene	$PM_{2.5}$	2.93E-05
7782492	Selenium	PM_{10}	2.83E-08
100425	Styrene	VOC	1.58E-03
108883	Toluene	VOC	2.40E-03

Table 2. Category 1 and 2 Hazardous Air Pollutant Speciation Profile for Underway Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
1330207	Xylene	VOC	3.60E-03
540841	2,2,4-trimethylpentane	VOC	2.50E-04
83329	Acenaphthene	$PM_{2.5}$	1.50E-05
208968	Acenaphthylene	$PM_{2.5}$	2.31E-05
75070	Acetaldehyde	VOC	4.64E-02
107028	Acrolein	VOC	2.19E-03
NH3	Ammonia	PM_{10}	2.31E-02
120127	Anthracene	$PM_{2.5}$	2.31E-05
7440382	Arsenic	PM_{10}	3.00E-05
56553	Benz[a]Anthracene	$PM_{2.5}$	2.50E-05
71432	Benzene	VOC	1.27E-02
50328	Benzo[a]Pyrene	PM_{10}	5.00E-06
205992	Benzo[b]Fluoranthene	PM_{10}	1.00E-05
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	5.63E-06
207089	Benzo[k]Fluoranthene	PM_{10}	5.00E-06
7440439	Cadmium	PM_{10}	5.15E-06
16065831	Chromium III	PM_{10}	3.30E-05
18540299	Chromium VI	PM_{10}	1.70E-05
218019	Chrysene	$PM_{2.5}$	4.38E-06
600	Dioxin	PM_{10}	5.00E-09
100414	Ethylbenzene	VOC	1.25E-03
206440	Fluoranthene	$PM_{2.5}$	1.38E-05
86737	Fluorene	$PM_{2.5}$	3.06E-05
50000	Formaldehyde	VOC	9.35E-02
118741	Hexachlorobenzene	PM_{10}	4.00E-08
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	1.00E-05
7439921	Lead	PM_{10}	1.50E-04
7439965	Manganese	PM_{10}	1.28E-06
7439976	Mercury	PM_{10}	5.00E-08
91203	Naphthalene	$PM_{2.5}$	8.76E-04
110543	n-Hexane	VOC	3.44E-03
7440020	Nickel	PM_{10}	1.00E-03
1336363	Polychlorinated Biphenyls	PM_{10}	5.00E-07

Table 2. Category 1 and 2 Hazardous Air Pollutant Speciation Profile for Underway Activities (Continued)

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
85018	Phenanthrene	$PM_{2.5}$	3.50E-05
123386	Propionaldehyde	VOC	3.81E-03
129000	Pyrene	$PM_{2.5}$	2.44E-05
7782492	Selenium	PM_{10}	5.15E-08
100425	Styrene	VOC	1.31E-03
108883	Toluene	VOC	2.00E-03
1330207	Xylene	VOC	3.00E-03

Table 3. Category 3 Hazardous Air Pollutant Speciation Profile for Hotelling Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
83329	Acenaphthene	$PM_{2.5}$	3.40E-07
208968	Acenaphthylene	$PM_{2.5}$	5.25E-07
75070	Acetaldehyde	VOC	2.29E-04
NH3	Ammonia	PM_{10}	1.08E-02
120127	Anthracene	$PM_{2.5}$	5.25E-07
7440382	Arsenic	PM_{10}	4.00E-04
56553	Benz[a]Anthracene	$PM_{2.5}$	5.67E-07
71432	Benzene	VOC	9.80E-06
50328	Benzo[a]Pyrene	PM_{10}	2.00E-06
205992	Benzo[b]Fluoranthene	PM_{10}	4.00E-06
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	1.28E-07
207089	Benzo[k]Fluoranthene	PM_{10}	2.00E-06
7440417	Beryllium	PM_{10}	5.46E-07
7440439	Cadmium	PM_{10}	5.90E-06
16065831	Chromium III	PM_{10}	3.96E-04
18540299	Chromium VI	PM_{10}	2.04E-04
218019	Chrysene	$PM_{2.5}$	9.93E-08
7440484	Cobalt	PM_{10}	2.92E-04
53703	Dibenzo[a,h]Anthracene	$PM_{2.5}$	0.00E+00
600	Dioxin	PM_{10}	2.00E-09

Table 3. Category 3 Hazardous Air Pollutant Speciation Profile for Hotelling Activities (Continued)

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
206440	Fluoranthene	$PM_{2.5}$	3.12E-07
86737	Fluorene	$PM_{2.5}$	6.95E-07
50000	Formaldehyde	VOC	1.57E-03
118741	Hexachlorobenzene	PM_{10}	1.60E-08
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	4.00E-06
7439921	Lead	PM_{10}	6.00E-05
7439965	Manganese	PM_{10}	5.73E-05
7439976	Mercury	PM_{10}	1.40E-06
91203	Naphthalene	$PM_{2.5}$	1.99E-05
7440020	Nickel	PM_{10}	1.54E-02
1336363	Polychlorinated Biphenyls	PM_{10}	2.00E-07
85018	Phenanthrene	$PM_{2.5}$	7.94E-07
7723140	Phosphorous	PM_{10}	4.38E-03
130498292	POM as 16-PAH	$PM_{2.5}$	2.49E-05
130498292	POM as 7-PAH	PM_{10}	4.50E-07
129000	Pyrene	$PM_{2.5}$	5.53E-07
7782492	Selenium	PM_{10}	9.08E-06

Table 4. Category 3 Hazardous Air Pollutant Speciation Profile for Maneuvering Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
83329	Acenaphthene	$PM_{2.5}$	3.40E-07
208968	Acenaphthylene	$PM_{2.5}$	5.25E-07
75070	Acetaldehyde	VOC	2.29E-04
NH3	Ammonia	PM_{10}	2.38E-03
120127	Anthracene	$PM_{2.5}$	5.25E-07
7440382	Arsenic	PM_{10}	8.74E-05
56553	Benz[a]Anthracene	$PM_{2.5}$	5.67E-07
71432	Benzene	VOC	9.80E-06
50328	Benzo[a]Pyrene	PM_{10}	4.37E-07
205992	Benzo[b]Fluoranthene	PM_{10}	8.74E-07

Table 4. Category 3 Hazardous Air Pollutant Speciation Profile for Maneuvering Activities (Continued)

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	1.28E-07
207089	Benzo[k]Fluoranthene	PM_{10}	4.37E-07
7440417	Beryllium	PM_{10}	5.46E-07
7440439	Cadmium	PM_{10}	2.26E-05
16065831	Chromium III	PM_{10}	1.27E-04
18540299	Chromium VI	PM_{10}	6.53E-05
218019	Chrysene	$PM_{2.5}$	9.93E-08
7440484	Cobalt	PM_{10}	5.94E-05
53703	Dibenzo[a,h]Anthracene	$PM_{2.5}$	0.00E+00
600	Dioxin	PM_{10}	4.37E-10
206440	Fluoranthene	$PM_{2.5}$	3.12E-07
86737	Fluorene	$PM_{2.5}$	6.95E-07
50000	Formaldehyde	VOC	1.57E-03
118741	Hexachlorobenzene	PM_{10}	3.50E-09
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	8.74E-07
7439921	Lead	PM_{10}	1.40E-05
7439965	Manganese	PM_{10}	5.73E-05
7439976	Mercury	PM_{10}	2.71E-07
91203	Naphthalene	$PM_{2.5}$	1.99E-05
7440020	Nickel	PM_{10}	3.25E-03
1336363	Polychlorinated Biphenyls	PM_{10}	4.37E-08
85018	Phenanthrene	$PM_{2.5}$	7.94E-07
7723140	Phosphorous	PM_{10}	1.79E-03
130498292	POM as 16-PAH	$PM_{2.5}$	2.49E-05
130498292	POM as 7-PAH	PM_{10}	4.90E-07
129000	Pyrene	$PM_{2.5}$	5.53E-07
7782492	Selenium	PM_{10}	1.91E-06

Table 5. Category 3 Hazardous Air Pollutant Speciation Profile for Underway Activities

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
83329	Acenaphthene	$PM_{2.5}$	3.40E-07
208968	Acenaphthylene	$PM_{2.5}$	5.25E-07

Table 5. Category 3 Hazardous Air Pollutant Speciation Profile for Underway Activities (Continued)

Pollutant Code	Pollutant	Speciation Basis	2008 Emission Factor
75070	Acetaldehyde	VOC	2.29E-04
NH3	Ammonia	PM_{10}	4.77E-03
120127	Anthracene	$PM_{2.5}$	5.25E-07
7440382	Arsenic	PM_{10}	1.75E-04
56553	Benz[a]Anthracene	$PM_{2.5}$	5.67E-07
71432	Benzene	VOC	9.80E-06
50328	Benzo[a]Pyrene	PM_{10}	8.74E-07
205992	Benzo[b]Fluoranthene	PM_{10}	1.75E-06
191242	Benzo[g,h,I,]Perylene	$PM_{2.5}$	1.28E-07
207089	Benzo[k]Fluoranthene	PM_{10}	8.74E-07
7440417	Beryllium	PM_{10}	5.46E-07
7440439	Cadmium	PM_{10}	2.26E-05
7440473	Chromium	PM_{10}	1.92E-04
16065831	Chromium III	PM_{10}	1.27E-04
18540299	Chromium VI	PM_{10}	6.53E-05
218019	Chrysene	$PM_{2.5}$	9.93E-08
7440484	Cobalt	PM_{10}	1.54E-04
53703	Dibenzo[a,h]Anthracene	$PM_{2.5}$	0.00E+00
600	Dioxin	PM_{10}	8.74E-10
206440	Fluoranthene	$PM_{2.5}$	3.12E-07
86737	Fluorene	$PM_{2.5}$	6.95E-07
50000	Formaldehyde	VOC	1.57E-03
118741	Hexachlorobenzene	PM_{10}	6.99E-09
193395	Indeno[1,2,3-c,d]Pyrene	PM_{10}	1.75E-06
7439921	Lead	PM_{10}	2.62E-05
7439965	Manganese	PM_{10}	5.73E-05
7439976	Mercury	PM_{10}	5.24E-07
91203	Naphthalene	$PM_{2.5}$	1.99E-05
7440020	Nickel	PM_{10}	5.89E-03
1336363	Polychlorinated Biphenyls	PM_{10}	8.74E-08
85018	Phenanthrene	$PM_{2.5}$	7.94E-07
7723140	Phosphorus	PM_{10}	5.73E-03
130498292	POM as 16-PAH	$PM_{2.5}$	2.49E-05
130498292	POM as 7-PAH	PM_{10}	4.90E-07
129000	Pyrene	$PM_{2.5}$	5.53E-07
7782492	Selenium	PM_{10}	3.48E-06

Appendix A-3

Nonroad 2008 Inventory Documentation for the Emissions Inventory Methodology for Commercial Marine Vessels, Locomotives, and Aircrafts

- Documentation of the Commercial Marine Vessel Component of the National Emissions Inventory Methodology
- Documentation of the Locomotive Component of the National Emissions Inventory Methodology
- Documentation of the Aircraft Component of the National Emissions Inventory Methodology

ERG No.: 0245.03.402.001
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Documentation for Locomotive Component of the National Emissions Inventory Methodology

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1.0 INTRODUCTION

1.1 What are Locomotive Sources?

The locomotive source category 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 does not include locomotives powered by electricity or steam. Emissions associated with the operation of electric locomotives would be included in the point source utility emission estimate. It is believed that the number of wood or coal driven steam locomotives is currently very small; therefore, these types of locomotives are not included in this inventory.

The locomotive source category is further divided up into three categories: Class I line haul, Class II/III line haul, and Class I yard. The national rail estimates were developed by the Eastern Regional Technical Advisory Committee hereafter referenced as ERTAC Rail. This group is comprised of eastern states' regulatory agencies in collaboration with the rail industry. ERTAC Rail developed emissions estimates based on fuel data obtained from the American Association of Railroads for each subcategory. California locomotive emission estimates were handled separately from the rest of the United States because of their use of low sulfur locomotive diesel fuels.

2.0 DEVELOPMENT OF THE LOCOMOTIVE COMPONENT FOR THE NEI

2.1 What Pollutants are Included in the National Emission Estimates for Locomotives?

All of the criteria pollutants, VOC, CO, NO_x, SO_x, PM, and $PM_{2.5}$, are included in the locomotive component of the NEI. OTAQ identified the HAPs for which data were available to develop inventory estimates (Scarbro, 2001). The hazardous air pollutants (HAPs), listed below, were identified based on available test data and accepted emission estimation procedures. Emission estimation methods have changed over the history of the NEI, as outlined briefly in Table 2-2 for nonroad sources.

Table 2-1. Locomotive Pollutant List

1,3-Butadiene	Beryllium	Napthalene
2,2,4-Trimethylpentane	Cadmium	n-Hexane
Acenaphthene	Chromium (Hexavalent)	Nickel
Acenaphthylene	Chromium (Trivalent)	Phenanthrene
Acetaldehyde	Chrysene	PAH Propionaldehyde
Acrolein	Dibenz(a,h) anthracene	Pyrene
Anthracene	Ethyl Benzene	Styrene
Arsenic	Fluoranthene	Toluene
Benzene	Fluorene	Xylene
Benzo(a)anthracene	Formaldehyde	
Benzo[a]pyrene	Indeno(1,2,3-cd) pyrene	
Benzo[b]fluoranthene	Lead	
Benzo[g,h,i,]perylene	Manganese	
Benzo[k]fluoranthene	Mercury	

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
NONROAD Categories			
Nonroad Gasoline, Diesel, LPG, CNG	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's National Mobile Inventory Model (NMIM), which incorporates NONROAD2008. Where states provided alternate NMIM nonroad inputs, these data replaced EPA default inputs.
	2005	VOC, NO_x, CO, SO_2, , PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's NMIM, which incorporates NONROAD2005. Where States provided alternate nonroad inputs, these data replaced EPA default inputs.
	2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3, & HAPs	Emission estimates for NONROAD model engines were developed using EPA's NMIM, which incorporates NONROAD2004. Where states provided alternate nonroad inputs, these data replaced EPA default inputs. State-supplied emissions data also replaced default EPA emission estimates.
	1999	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) an updated 1999 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. Replaced State-submitted data for California for all NONROAD model categories; Pennsylvania for recreational marine and aircraft ground support equipment, and Texas for select equipment categories.
	1996, 1997, 1998, 2000 & 2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated year-specific national and California inventories, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios and California county-to-state ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model. California results replace the diesel equipment emissions generated from prior application of county-to-national ratios.

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1990 and 1996 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1990 and 1996. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1990 county-level emissions to estimate 1991-1995 emissions.
	1990	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1990 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1986, 1988, & 1989	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3	Using 1985 and 1990 county-level emissions inventories, estimated emissions using linear interpolation of national emissions between 1985 and 1990. From these emissions, calculated the average annual growth rate for each pollutant/SCC combination for each year, and then applied the growth factors to 1985 county-level emissions to estimate 1986-1989 emissions.
	1987	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for 1987 by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.
	1985	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using emission estimates from two emission inventories including: 1) a 1996 county-level inventory, developed using EPA's October 2001 draft NONROAD model; and 2) updated 1985 national inventory, based on EPA's draft Lockdown C NONROAD model (dated May 2002). Using the 1996 county-level emission estimates, seasonal and daily county-to-national ratios were then developed for application to updated national estimates per season estimated from the Lockdown C model.
	1970, 1975, 1978, & 1980	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Using EPA's draft Lockdown C NONROAD model (dated May 2002), developed updated national emissions for all years by running 4 seasonal NONROAD model runs to estimate annual criteria pollutant emissions. Also performed national NONROAD model runs to estimate typical summer weekday emissions.

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Nonroad Gasoline, Diesel, LPG, and CNG (Continued)	1996, 1997, 1998, 1999, 2000, & 2001	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD. NH_3 emissions for California were also recalculated using updated diesel fuel consumption values generated for California-specific runs, and assuming the 1996 county-level distribution.
	1985 & 1990	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model, multiplying by NH_3 emission factors, and distributing to counties using 1996 inventory, based on October 2001 draft NONROAD.
	1987	NH_3	Obtaining 1987 national fuel consumption estimates from Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1970, 1975, 1978, & 1980	NH_3	Obtaining national fuel consumption estimates from the Lockdown C NONROAD model and multiplying by NH_3 emission factors.
	1990, 1996, & 1999	HAPs	Speciation profiles applied to county VOC and PM estimates. Metal HAPs were calculated using fuel and activity-based emission factors. Some state data were provided and replaced national estimates. (2003)
Aircraft			
Commercial Aircraft	2008	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)
	2002 and 2005	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) was run for criteria pollutants, VOC and PM emissions were speciated into HAP components. (2004)
	1990, 1996, 1999, 2000, 2001	VOC, NO_x, CO, SO_x	Input landing and take-off (LTO) data into FAA EDMS. National emissions were assigned to airports based on airport specific LTO data and BTS GIS data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2003)
General Aviation, Air Taxis	2008	Criteria and HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO for aircraft identified as Air taxis. (2010) Used FAA LTO data from TAF and OTAQ provided activity data for smaller airports derived from FAA 5010 master plans. EPA approved generic emission factors for criteria estimates. Speciation profiles were applied to VOC and PM estimates to get national HAP estimates. (2010)

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
General Aviation, Air Taxis (Continued)	2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2002 emissions for approximately 4,000 largest airports were calculated via EDMS and SIP guidance and included in the 2005 NEI as point sources. Only airports in FAA's T100 and TAF databases were included. State point source submittals were incorporated.
	1978, 1987, 1990, 1996, 1999, 2000, 2001, & 2002	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to get national HAP estimates. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	Used FAA LTO data and EPA approved emission factors for criteria estimates. Speciation profiles were applied to VOC estimates to develop national HAP estimates. (2004)
	1990, 1996, 1999, & 2002	Pb	Used Department of Energy (DOE) aviation gasoline usage data with lead concentration of aviation gasoline. (2004)
	1996	NH_3	Applied NH_3 emissions factors to 1996 national jet fuel and aviation gasoline consumption estimates.
Military Aircraft	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed. (2010)
	2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2002 emissions were included in the 2005 NEI as point sources similar to other TAF reported data.
	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, 2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Used FAA LTO data as reported in TAF and EPA approved emission factors for criteria estimates. Representative HAP profiles were not readily available, therefore HAP estimates were not developed.
	1970-1998	VOC, NO_x, CO, SO_X, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
Auxiliary Power Units and Ground Support Equipment	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, HAPs	Federal Aviation Administration (FAA) Emissions and Dispersion and Modeling System (EDMS) - Version 5.1.was run using BTS T-100 LTO data. (2009)
	2002 and 2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, HAPs	Computed via NONROAD2005 model runs
	1985-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using LTO operations data from the FAA. Estimation methods prior to 1996 reported in EPA, 1998.

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Unpaved Airstrips[1]	1985-2001	PM_{10}, $PM_{2.5}$	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Aircraft Refueling[1]	1985-2001	VOC	Grew 1996 emissions to each year using SIC 45-Air Transportation growth factors, consistent with the current draft version of EGAS. Estimation methods prior to 1996 reported in EPA, 1998.
Commercial Marine Vessel (CMV)			
All CMV Categories	2008	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	OTAQ provided CAP emission estimates for all CMV categories. Note that the SCCs for this category have changed such that the Diesel category refers to smaller vessels (Category 1 and 2) using distillate fuels and the Residual category refers to larger (Category 3) vessels using a blend of residual fuels. Emissions were allocated to segments using GIS shapefiles and adjusted based on limited state data (2010)
	2008	HAPs	OTAQ's 2008 estimates were speciated into HAP components using SEPA profiles (2009)
CMV Diesel	2002 and 2005	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	2001 Estimates carried over. Used state data when provided. (2004)
		HAPs	1999 Estimates carried over. Used state data when provided. (2004)
	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Used criteria emission estimates in the background document for marine diesel regulations for 2000. Adjusted 2000 criteria emission estimates for other used based on fuel usage. Emissions were disaggregated into port traffic and underway activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
	1996	NH_3	Applied NH_3 emissions factors to 1996 distillate and residual fuel oil estimates (i.e., as reported in EIA, 1996).
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)
(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
CMV Steam Powered	2005	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$, HAPs	2002 estimates grown to 2005 (2008).
	2002	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$, HAPs	2002 based estimates were developed for port and underway category 3 (C3) vessels as part of a rulemaking effort. Emissions were developed separately for near port and underway emissions. For near port emissions, inventories for 2002 were developed for 89 deep water and 28 Great Lake ports in the U.S. The Waterway Network Ship Traffic, Energy, and Environmental Model (STEEM) was used to provide emissions from ships traveling in shipping lanes between and near individual ports (2008)
	1978, 1987, 1990, 1996, 1999, 2000, & 2001	VOC, NO_x, CO, SO_x, PM_{10}, & $PM_{2.5}$	Calculated criteria emissions based on EPA SIP guidance. Emissions were disaggregated into port traffic and under way activities. Port emissions were assigned to specific ports based on amount of cargo handled. Underway emissions were allocated based on Army Corp of Engineering waterway data. State data replaced national estimates. (2003)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, & 1999	HAPs	VOC and PM emission estimates were speciated into HAP components. State data replaced national estimates. (2003)
Military Marine	1997-2001	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CMV Coal,[2] CMV, Steam powered, CMV Gasoline[2]	1997-1998	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Applied EGAS growth factors to 1996 emissions estimates for this category.
CM Coal, CMV, Steam powered, CMV Gasoline, Military Marine	1991-1995	VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$	Estimation methods reported in EPA, 1998.
Locomotives			
Class I, II, III and Yard operations	**2008**	**VOC, NO_x, CO, PM_{10}, $PM_{2.5}$, SO_x & HAPs**	**Criteria emission estimates were provided to EPA by ERTAC. These data were assigned to individual railway segments using DOT shapefiles and guidance from ERTAC. HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. (2010)**

Table 2-2. Methods Used to Develop Annual Emission Estimates for Nonroad Mobile Sources (Continued)

(Categories included in this report are noted in bold print)

Category	Base Year	Pollutant(s)	Estimation Method*
Class I, Class II, Commuter, Passenger, and Yard Locomotives	1978, 1987, 1990, 1996, 1999, 2000, 2000, 2002, & 2005	VOC, NO_x, CO, PM_{10}, $PM_{2.5}$	Criteria pollutants were estimated by using locomotive fuel use data from DOE EIA and available emission factors. County-level estimates were obtained by scaling the national estimates with the rail GIS data from DOT. State data replaced national estimates. (2004)
	1978, 1987, 1990, 1996, 1999, 2000, 2001, 2002, & 2005	SO_2	SO_x emissions were calculated by using locomotive fuel use and fuel sulfur concentration data from EIA. County-level estimates were obtained by scaling the national estimates with the county level rail activity data from DOT. State data replaced national estimates. (2004)
	1970-1998	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$	Estimated emissions for interim years using linear interpolation between available base years. (2003)
	1990, 1996, 1999, & 2002	HAPs	HAP emissions were calculated by applying speciation profiles to VOC and PM estimates. County-level estimates were obtained by scaling the national estimates with the county level rail activity from DOT. State data replaced national estimates. (2004)
	1997-1998	NH_3	Grew 1996 base year emissions using EGAS growth indicators.
	1996	NH_3	Applied NH_3 emissions factors to diesel consumption estimates for 1996.
	1990-1995	NH_3	Estimation methods reported in EPA, 1998.

Notes:

* Dates included at the end of Estimation Method represent the year that the section was revised.

1 Emission estimates for unpaved airstrips and aircraft refueling are included in the area source NEI, since they represent non-engine emissions.

2 National Emission estimates for CMV Coal and CMV Gasoline were not developed though states and local agencies may have submitted estimates for these source categories.

EPA, 1998. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Emission Factors and Inventory Group, National Air Pollutant Emission Trends, Procedures Document, 1900–1996, EPA-454/R-98-008. May 1998.

3.0 HOW WERE LOCOMOTIVE EMISSIONS ESTIMATED?

ERTAC Rail used confidential railroad-provided data to generate railroad-specific criteria emission estimates for line haul and rail yards at the rail segment and rail yard level, respectively. Appendices A-C provide more detail on how emissions were developed and includes critical data used in calculating these estimates. This section of the report describes the emission estimating methods used in general terms as well as the approach for reallocating the emissions to protect confidential data. The data and documentation provided with respect to ERTAC Rail's emission estimates pertain to the version that was incorporated into the NEI and does not reflect recent revisions.

3.1 Line Haul Criteria Emissions Estimates

Criteria pollutant emissions were estimated by applying emission factors to the total amount of distillate fuel oil used by line haul locomotives. Fuel usage was obtained from publically available Class I Railroad Annual Reports (Form R-1). The R-1 reports are submitted to the Surface Transportation Board annually and include financial and operations data to be used in monitoring rail industry health and identifying changes that may affect national transportation policy. Additionally, each railroad provided fleet mix information that allowed ERTAC Rail to calculate railroad-specific emission factors. Weighted Emission Factors (EF) per pollutant for each gallon of fuel used (gm/gal or lbs/gal) were calculated for each Class I railroad fleet based on its fraction of line haul locomotives at each regulated Tier level. EPA emission factors were used for $PM_{2.5}$, SO_2, and NH_3.

The weighted emission factors were then applied to the link-specific fuel consumption to obtain emissions for each rail segment. Given the confidentiality of the activity data, emissions for criteria pollutants were provided to EPA by ERTAC Rail by county for Class I line haul. Class II/III rail was provided by railroad company and county. Appendices A and B provide more detail on the Class I and Class II/III line haul emission development, respectively.

3.2 Rail Yard Criteria Emissions Estimates

Rail yard locations were identified using a database from the Federal Railroad Administration. Criteria pollutant emissions were estimated by applying emission factors to the total amount of distillate fuel used by locomotives. Each railroad provided fleet mix information that allowed ERTAC to calculate railroad-specific emission factors. The company-specific, system wide fleet mix was used to calculate weighted average emissions factors for switchers operated by each Class I railroad. EPA emission factors were used for $PM_{2.5}$, SO_2, and NH_3.

R-1 report-derived fuel use was allocated to rail yards using an approximation of line haul activity data within the yard; see Appendix C for more details. These fuel consumption values were further revised by direct input from the Class I railroads. The weighted emission factors were then applied to the yard-specific fuel consumption to obtain emissions for each yard. Since the rail yard inventory was based on publically-available data, the final criteria emission estimates were provided per rail yard.

3.3 Hazardous Air Pollutant Emissions Estimates

HAP emissions were estimated by applying speciation profiles to the VOC or PM estimates. The speciation profiles were derived from *Evaluation of Factors that Affect Diesel Exhaust Toxicity* (Truex and Norbeck, 1998), and data provided by OTAQ (Scarbro, 2001 and 2002). It should be noted that since California uses low sulfur diesel fuel and emission factors specific for California railroad fuels were available, calculations of the state's emissions were done separately from the other states. The HAP speciation profile used in this effort is shown in Table 3-1. HAP estimates were calculated at the yard and link level, after the criteria emissions had been allocated.

Table 3-1. Hazardous Air Pollutant Speciation Profile for 2008 Locomotive Emission Estimation

Pollutant Name	California	All Other States	Speciation Base
1,3 Butadiene	0.0000615	0.0047735	PM_{10}
2-2-4 Trimethylpentane	0.0022425	0.0022425	VOC
Acenaphthene	0.0000080	0.0000306	PM_{10}
Acenaphthylene	0.0002182	0.0004275	PM_{10}
Acetaldehyde	0.0004492	0.0276274	PM_{10}
Acrolein	0.0000855	0.0045943	PM_{10}
Anthracene	0.0000535	0.0001009	PM_{10}
Arsenic	0.0000004	0.0000004	PM_{10}
Benzene	0.0000517	0.0038020	PM_{10}
Benzo(a)anthracene	0.0000121	0.0000160	PM_{10}
Benzo(a)pyrene	0.0000044	0.0000027	PM_{10}
Benzo(b)fluoranthene	0.0000044	0.0000064	PM_{10}
Benzo(ghi)perylene	0.0000044	0.0000031	PM_{10}
Benzo(k)fluoranthene	0.0000044	0.0000052	PM_{10}
Beryllium	0.0000280	0.0000280	PM_{10}
Cadium	0.0000280	0.0000280	PM_{10}
Chromium (III)	0.0000001	0.0000040	PM_{10}
Chromium (VI)	0.0000000	0.0000021	PM_{10}
Chrysene	0.0000092	0.0000119	PM_{10}
Dibenz(a,h)anthracene	0.0000000	0.0000000	PM_{10}
Ethylbenzene	0.0020000	0.0020000	VOC
Fluoranthene	0.0000601	0.0000746	PM_{10}
Fluorene	0.0000619	0.0001407	PM_{10}
Formaldehyde	0.0009451	0.0636582	PM_{10}
Indeno(1,2,3-cd)pyrene	0.0000033	0.0000027	PM_{10}
Lead	0.0000840	0.0000840	PM_{10}
Manganese	0.0000020	0.0000020	PM_{10}
Mercury	0.0000280	0.0000280	PM_{10}
Napthalene	0.0018505	0.0025756	PM_{10}
n-Hexane	0.0055000	0.0055000	VOC

Table 3-1. Hazardous Air Pollutant Speciation Profile for 2008 Locomotive Emission Estimation (Cont.)

Pollutant Name	California	All Other States	Speciation Base
Nickel	0.0000066	0.0000066	PM_{10}
Phenanthrene	0.0002822	0.0005671	PM_{10}
Propionaldehyde	0.0061000	0.0061000	VOC
Pyrene	0.0000771	0.0001054	PM_{10}
Styrene	0.0021000	0.0021000	VOC
Toluene	0.0032000	0.0032000	VOC
Xylene	0.0048000	0.0048000	VOC

4.0 HOW WERE COUNTY LINE HAUL EMISSIONS REALLOCATED TO INDIVIDUAL RAIL SEGMENTS?

4.1 Class I Line Haul Emissions Allocation

Class I line haul emissions were allocated to rail segments based on segment-specific railroad traffic data (ton miles) obtained from the Department of Transportation (BTS, 2009). This dataset categorizes the segments' level of activity into ranges of MGTM and is populated by FRA. Emissions were divided between all mainline segments using these activity ranges as a proxy to allocate more emissions to segments with higher activity.

Since the activity data were provided as ranges, a single "allocation value", typically the midpoint of the range, was selected for use in the emissions allocation. The exception to this was the "0" activity category, which by definition had "unknown" activity. As a result, most mainline segments with the "0" activity category were not included in the emissions calculation/allocation. However, there was a small subset of segments that did have known activity values in the confidential data set but were labeled as "unknown" in the publically available data set. Those segment IDs were provided by ERTAC Rail for inclusion in the emission allocation; however, the activity of these segments was averaged to protect confidential data. Table 4-1 lists the activity categories along with their ranges in MGTM/mi and the allocation value used in the emissions spatial allocation.

Table 4-1. Line Haul Segment Activity (MGTM/Mi) Categories

Category	Range Minimum	Range Maximum	Allocation Value Used
0*	0.0003	0.09	0.01233
1	0.1	4.9	2.5
2	5	9.9	7.45
3	10	19.9	14.95
4	20	39.9	29.95
5	40	59.9	49.95
6	60	99.9	79.95
7	100	1000000	100

* The "0" category has "unknown" activity in the publically available segment data. As a result, this table lists the minimum, maximum, and average of the confidential activity data greater than zero that were categorized as "unknown" in the public data.

The county emission sums were reallocated to the segments by multiplying the county emissions by the segment's allocation value divided by the sum of the allocation values for all links within the county.

$$E_{iL} = E_{iC} * \frac{A_L}{\sum_{C=1}^{N} A_{LC}}$$

Where:

E_{iL} = Emissions of pollutant i per link L (tons/year).
E_{iC} = Emissions of pollutant i per county C (tons/year).
A_L = Allocation value for link L per activity category from public BTS dataset
A_{LC}= Sum of allocation values for all links in county C from public BTS dataset

Note that rail line data for Puerto Rico, U.S. Virgin Islands, and Hawaii data were not included in ERTAC Rail's shapefile and were developed separately; however, since these areas have exclusively Class II/III railroads present, these efforts are discussed in the following section.

4.2 Class II/III Line Haul Emissions Allocation

ERTAC Rail created a shapefile of Class II/III mainline rail segments from their FRA-provided proprietary shapefile as described in Appendix B for the contiguous 48 states and Alaska. Raw rail line data for Puerto Rico were obtained from USGS (Scanlon and Briere, 2000), and rail line data for Hawaii was obtained from ESRI's Digital Chart of the World (ESRI 2010). The U.S. Virgin Islands have no rail lines. Because Class II/III railroads are less likely to use rail segments that are heavily traveled by Class I railroads, the activity-based approach used for Class I lines was not appropriate. Instead, Class II/III line haul emissions were allocated to rail segments using segment length as a proxy.

The county emission sums were reallocated to the segments by multiplying the county emissions by the segment's length divided by the sum of the length for all links within the county.

$$E_{iL} = E_{iC} * \frac{l_L}{\sum_{C=1}^{N} l_{LC}}$$

Where:

E_{iL} = Emissions of pollutant i per link L (tons/year).
E_{iC} = Emissions of pollutant i per county C (tons/year).
l_L = Allocation value for link L per activity category from public BTS dataset
l_{LC} = Sum of allocation values for all links in county C from public BTS dataset

Since ERTAC Rail used proprietary data to develop the shapefile, some segment IDs were not found in the EIS data set. These segments were manually identified, and their emissions were allocated to the nearest segment within the EIS data set.

4.3 Rail Yard Emissions Allocation

Rail yard emissions were developed based on yard name and ownership properties. As a result, unique yards needed to be identified and emissions summed. Unfortunately, the yard data lacked detail necessary for confident duplicate checks and yard matching such as address, detailed yard name, etc. As a result, a GIS was used to find the centroid of the yards based on the latest public BTS rail network, using the yard name and FIPS. The list of unique yards was further examined against ERTAC's data and within Google Earth to identify any yards that required further revision. A crosswalk of original ERTAC data to new, consolidated yard IDs facilitated the summing of activity and emissions. 753 unique yards were identified nationwide. This underestimate of the total number of yards is most likely due to using line-haul-focused data to identify locations and develop rail yard emissions.

Once the unique yards were identified and criteria emissions were summed at the yard, the PM and VOC-based HAP speciation profile was applied to estimate HAP emissions at each yard.

4.4 State Provided Data

In this version of NEI, state and local agencies were invited to provide locomotive data that replaced the estimates based on national fuel consumption. However, only a small rail yard dataset was received from Kentucky. Their rail yard list was compared with the ERTAC/ERG yard list, and 2 yards were found in both sets. These yards were merged so as to avoid duplication in activity or emissions.

4.5 What are the Results?

Table 3 summarizes the 2008 locomotive mobile source emission estimates.

Table 3. 2008 Locomotive Emissions Data

2008 Locomotive Criteria Emissions				
Pollutant Name	**Class I Line Haul**	**Class II/III Line Haul**	**Rail Yard**	**TOTAL**
CO	110,969	5,055	9,152	125,176
NH_3	347	16	27	390
NO_X	754,433	51,342	73,741	879,516
PM_{10}-PRI	25,477	1,264	2,086	28,827
PM_{25}-PRI	23,439	1,163	2,024	26,626
SO_2	7,836	357	619	8,811
VOC	37,941	1,896	4,824	44,661
2008 Locomotive Hazardous Air Pollutant Emissions				
Pollutant Name	**Class I Line Haul**	**Class II/III Line Haul**	**Rail Yard**	**TOTAL**
1,3 Butadiene	116.7941	5.7969	9.3296	131.9206
2-2-4 Trimethylpentane	85.0832	4.2511	10.8178	100.1521
Acenaphthene	0.7569	0.0376	0.0609	0.8554

Table 3. 2008 Locomotive Emissions Data (Cont.)

2008 Locomotive Hazardous Air Pollutant Emissions				
Pollutant Name	**Class I Line Haul**	**Class II/III Line Haul**	**Rail Yard**	**TOTAL**
Acenaphthylene	10.6772	0.5298	0.8639	12.0709
Acetaldehyde	676.0572	33.5552	54.0089	763.6213
Acrolein	112.4351	5.5806	8.9828	126.9985
Anthracene	2.5231	0.1252	0.2042	2.8525
Arsenic	0.0091	0.0005	0.0007	0.0103
Benzene	93.0272	4.6173	7.4312	105.0757
Benzo(a)anthracene	0.4047	0.0201	0.0329	0.4577
Benzo(a)pyrene	0.0717	0.0036	0.0059	0.0812
Benzo(b)fluoranthene	0.1607	0.0079	0.0131	0.1817
Benzo(ghi)perylene	0.0798	0.0040	0.0066	0.0904
Benzo(k)fluoranthene	0.1312	0.0065	0.0107	0.1484
Beryllium	0.7138	0.0354	0.0584	0.8076
Cadium	0.7138	0.0354	0.0584	0.8076
Chromium (III)	0.0985	0.0049	0.0079	0.1113
Chromium (VI)	0.0508	0.0025	0.0041	0.0574
Chrysene	0.2998	0.0149	0.0244	0.3391
Ethylbenzene	75.8814	3.7914	9.6479	89.3207
Fluoranthene	1.8868	0.0936	0.1538	2.1342
Fluorene	3.5039	0.1739	0.2830	3.9608
Formaldehyde	1,557.66	77.3124	124.4335	1759.4059
Indeno(1,2,3-cd)pyrene	0.0684	0.0034	0.0056	0.0774
Lead	2.1413	0.1062	0.1753	2.4228
Manganese	0.0520	0.0026	0.0043	0.0589
Mercury	0.7138	0.0354	0.0584	0.8076
Napthalene	64.8766	3.2187	5.2765	73.3718
n-Hexane	208.6739	10.4263	26.5317	245.6319
Nickel	0.1669	0.00983	0.0137	0.19043
Phenanthrene	14.1555	0.7024	1.1450	16.0029
Propionaldehyde	231.4383	11.5637	29.4261	272.4281
Pyrene	2.6566	0.1318	0.2161	3.0045
Styrene	79.6755	3.9809	10.1303	93.7867
Toluene	121.4103	6.0662	15.4366	142.9131
Xylene	182.1154	9.0993	23.1549	214.3696

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Appendix A

ERTAC Class I Line Haul Documentation

DRAFT

ERTAC Rail Emissions Inventory
Part 1: Class I Line-Haul Locomotives

Michelle Bergin, GA Environmental Protection Division
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Acknowledgments:
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Raquel Wright, Federal Railroad Administration
Julie McDill, Mid-Atlantic Regional Air Management Association
Patrick Davis, Mid-Atlantic Regional Air Management Association
Laurel Driver, US EPA, Office of Air Quality Planning and Support
Byeong Kim, GA Environmental Protection Division

Introduction

Air protection agencies from twenty-seven states, coordinated through the Eastern Regional Technical Advisory Committee (ERTAC) and headed by the Lake Michigan Air Directors Consortium (LADCO), identified a need to better quantify and characterize rail-related emissions inventories. Traditional locomotives largely utilize diesel engines, resulting in emissions of NO_x, diesel PM, hydrocarbons, greenhouse gases, and other pollutants. These emissions are sometimes concentrated in areas exceeding National Ambient Air Quality Standards. No cohesive nationwide railroad emission estimates based on local operations are known to have been made previously. Inventory development methods for locomotive emissions estimates vary from state to state and, in general, lack the spatial or temporal resolution needed to support air quality modeling and planning [1-5].

The ERTAC Rail Subcommittee (ERTAC Rail) was established with active representatives from twelve member states, three regional planning offices, and the US EPA. The subcommittee's goals are to (1) standardize agencies' inventory development methods through a collaborative effort, (2) improve the quality of data received and the resulting emission inventories, and (3) reduce the administrative burden on railroad companies of providing data.

With support from the Rail industry and assistance from the ERTAC Rail Data Workgroup (Appendix A), ERTAC Rail has developed 3 inventories of locomotive emissions (Table 1); from Class I line-haul, Shortline and Regional Railroads (Class II and III operations), and Class I railyard switchers. Because of the difficulty in obtaining data and differences in states' needs for inventory years, sources from both 2007 and 2008 were utilized (Appendix B.) Due to the variability and uncertainty in much of the data, the results are considered applicable for either 2007 or 2008.

The Surface Transportation Board (STB) defines Class I Railroads as having had minimum carrier operating revenues of $401.4 million (USD) in 2008. There are 8 Class I Railroads operating in the United States (Table 2), about 12 Regional Railroads (Class II), and approximately 530 Class III Railroads (Shortlines). While categorized as a Class I Railroad, Amtrak was excluded from these inventories because of significant differences in equipment and operation characteristics. Line-haul locomotives travel long distances (e.g. between cities) while switcher locomotives largely operate in railyards, splitting and joining rail cars with varying destinations. Passenger and Commuter Rail (including Amtrak), industrial locomotives, and associated non-locomotive equipment are not included in these inventories.

This paper documents the data sources and methodologies used for calculating the Class I line-haul emissions inventory. Class I line-haul activities are the largest source of rail-related emissions, with estimates of Class I line-haul fuel consumption totals to be from 74 to 84% of all rail sources combined[4, 5]. For this reason, characterizing Class I line-haul emissions were a focal point of ERTAC Rail's inventory development efforts. Information on ERTAC Rail, Railroad participation, the Rail industry, and effects of rail on air quality are available elsewhere[6].

Table 1. Summary of ERTAC Rail Inventories: U.S. Locomotive Emissions and Fuel Use for either 2007 or 2008*.

	Fuel Use** (gal/yr)	Emissions (tons/yr)					
		NO_x	$PM_{2.5}$	HC	SO_2	CO	NH_3
Class I*** line-haul	3,770,914,002	754,443	23,439	37,941	7,836	110,969	347
Class I switcher	300,492,223	73,741	2,024	4,824	619	9,152	27
Class II and III	157,800,000	51,367	1,163	1,897	357	5,058	16

*See Appendix B for a description of the year and source of data utilized for each inventory.
**Locomotive grade diesel
***Excluding Amtrak and including work train fuel use

Table 2. Class I Railroads, Reported Locomotive Fuel Use, and Railroad Fuel Consumption Index (RFCI) [7].

Class I Railroads*	R-1 Reported Locomotive Fuel Use (gal/yr)		RFCI (ton-miles/gal)
	Line-Haul (2007)**	Switcher (2008)	
BNSF	1,393,874,954	52,497,057	883.14
Canadian National	93,830,751	12,290,022	1190.79
Canadian Pacific***	50,320,233	4,594,067	1096.28
CSX	514,687,186	53,717,674	963.81
Kansas City Southern	69,787,071	1,816,759	785.89
Norfolk Southern	463,267,278	32,317,375	865.75
Union Pacific	1,185,146,529	143,470,336	974.64
Total	**3,770,914,002**	**300,492,223**	**929.47**

* Excluding Amtrak
** Includes work trains
*** CP's line-haul fuel use values include 2008 data (rather than 2007) for their Delaware and Hudson subsidiary.

Method

Earlier efforts to characterize line-haul railroad emissions relied on highly aggregated activity data (Figure 1), and generally apportioned annual system-wide fuel use equally across all route miles of track operated by a Class I railroad. However, the majority of freight tonnage carried by Class I railroads is concentrated on a disproportionately small number of route miles. In addition, emissions calculations were previously based on an estimate of annual nationwide-average locomotive fleet mix to create one set of emissions factors.

For this inventory, the Class I Railroads allowed ERTAC Rail access under a confidentiality agreement to a link-level (single lengths of track) line-haul GIS layer activity dataset managed by the Federal Railroad Administration[9]. Each railroad also provided fleet mix information that allowed ERTAC Rail to calculate weighted emission factors based on the fraction of their line-haul fleet meeting each Tier level category. The use of this data, largely following a line-haul inventory methodology recommended by Sierra Research[2, 3], resulted in a link-level line-haul locomotive emission inventory using railroad-specific emission factors. This segment-level inventory is nationwide, aggregated to state and county level files, and will be released as gridded emissions files for use in photochemical and dispersion modeling. Link-level emissions may be provided for special study requests pending approval of any Class I railroads operating in the study domain. The calculations are described below as a two-part process, calculating railroad-specific factors and emissions per rail link.

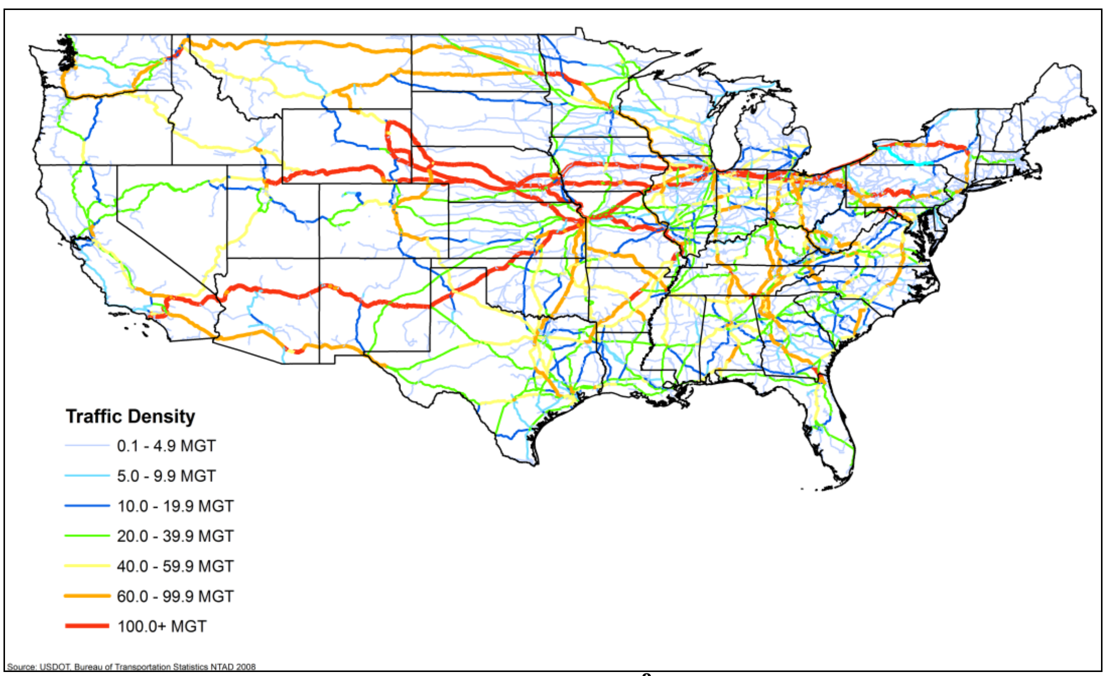

Figure 1. US Railroad Traffic Density in 2006.[8] MGT is million gross tons.

1. Calculate Railroad-Specific Factors.

The EPA provides annual default Emission Factors for locomotives based on characteristic operating cycles ('duty cycles') and the estimated nationwide fleet mixes for both switcher and line-haul locomotives. However, fleet mixes vary from railroad to railroad and, as can be seen in Figure 2, Class I railroad activity is highly regionalized in nature and subject to issues of local terrain such as operation on plains vs. mountainous areas, which can have a significant impact on fuel consumption and emissions.

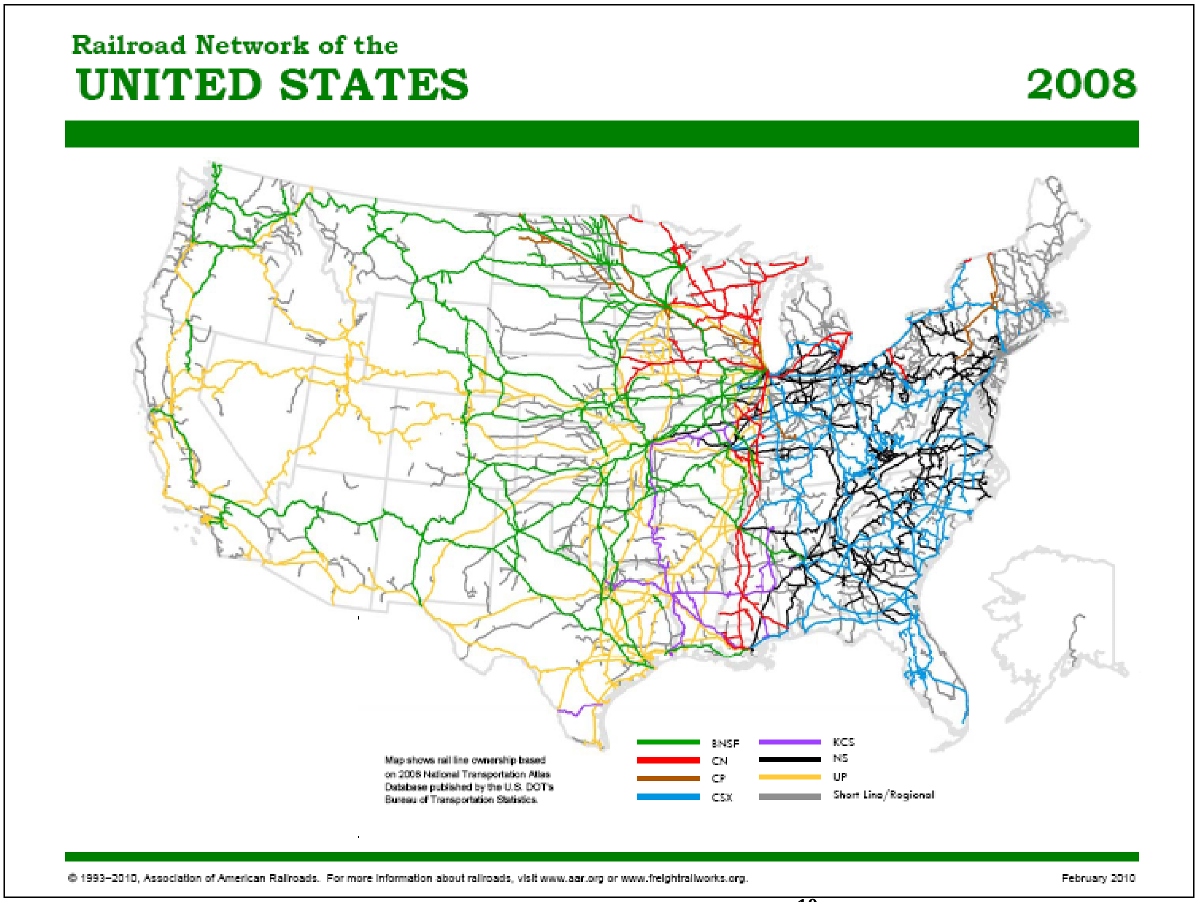

Figure 2. Class I Railroad Territories in the United States[10].

As an alternative approach to using a single nationwide set of emission factors, ERTAC Rail requested each Class I company to provide a description of their line-haul fleet mix based on Tier rating, which each company provided under a confidentiality agreement. An engine's Tier level is based on the year the engine was built and determines allowable emission limits (Table 3).

Table 3. EPA line-haul locomotive Emission Factors by Tier, 1997 standards (grams/gal). Note that the new standards released in 2008 did not apply to fleets in the year 2008. [11]

	PM_{10}	HC	NO_x	CO
Uncontrolled (pre-1973)	6.656	9.984	270.4	26.624
Tier 0 (1973-2001)	6.656	9.984	178.88	26.624
Tier 1 (2002-2004)	6.656	9.776	139.36	26.624
Tier 2 (2005 +)	3.744	5.408	102.96	26.624

Based on values in EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009.

Weighted Emission Factors (EF) per pollutant for each gallon of fuel used (gm/gal or lbs/gal) were calculated for each Class I railroad fleet based on its fraction of line-haul locomotives at each regulated Tier level (Eqn 1; Table 3).

$$EF_{iRR} = \sum_{T=1}^{4} (EF_{iT} * f_{TRR}) \qquad \text{Equation 1}$$

EF_{iRR} = Weighted Emission Factor for pollutant i for Class I railroad RR (gm/gal).
EF_{iT} = Emission Factor for pollutant i for locomotives in Tier T (gm/gal) (Table 3). There were 4 Tiers of locomotives in the 2008 fleets.
f_{TRR} = Fraction of railroad RR fleet in Tier T.

While engine emissions are variable within Tier categories, this approach likely provides better regional estimates than uniformly applying the nationwide average emission factors. This approach likely provides conservative emission estimates as locomotive engines are certified to meet or exceed the emissions standard for each Tier, although emission levels may increase after certification.

Other emission factors are not engine specific. For locomotives, $PM_{2.5}$ is assumed to be 97% of PM_{10} [11], and emission factors applied for SO_2 and NH_3 are 1.88 g/gal [11] and 83.3 mg/gal [12] respectively. Greenhouse gases are estimated using emission factors shown in Table 4.

Table 4. EPA greenhouse gas emission factors for locomotive diesel fuel (grams/gal). [13]

	CO_2	N_2O	CH_4
Locomotive diesel	1.015E4	0.26	0.80

A Railroad Fuel Consumption Index (RFCI) was also calculated for each Class I railroad using their system-wide line-haul fuel consumption (FC) and gross ton-mile (GTM) data reported in their annual R-1 reports submitted to the Surface Transportation Board[7] (Eqn 2). This value represents the average number of GTM produced per gallon of diesel fuel used over their system in a year, and varies between railroad carriers depending on factors such as fleet mix, system terrain, speeds, loading/weight of cargo, train type (e.g., intermodal, unit, and manifest), and operating practices. (Table 2).

$$RFCI_{RR} = \frac{GTM_{RR}}{FC_{RR}} \qquad \text{Equation 2}$$

$RFCI_{RR}$ = Railroad Fuel Consumption Index (gross ton-miles/gal) per Class I railroad (RR).
GTM_{RR} = Gross Ton-Miles (GTM), annual system-wide gross ton miles of freight transported per RR. (R-1 Report Schedule 755, Line 104)
FC_{RR} = Annual system-wide fuel consumption by line-haul and work trains per RR (gal) (R-1 Report Schedule 750, Lines 1 and 6).

2. Calculate Emissions per Link.

Emissions of pollutant i per link L (E_{iL}) are then calculated by multiplying the gallons of diesel fuel consumed by each Class I railroad on the link by that railroad's weighted Emission Factor for the pollutant, and summed over all railroads operating on the link (Eqn 3). This approach splits the activity on each link (represented by MGT) evenly between all railroads operating on the link. Note that the weighted Emission Factors are converted to tons/gal for these calculations, and that variables with units in tons may represent tons of freight hauled (MGT, RFCI) or tons of pollutants (EF, E).

$$E_{iL} = \sum_{RR=1}^{N} \frac{\left(\frac{MGT_L * 10^6}{N}\right) * l_L}{RFCI_{RR}} * EF_{iRR} \qquad \text{Equation 3}$$

E_{iL} = Emissions of pollutant i per link L (tons/year).
N = Number of Class I railroads operating on link L.
MGT_L = Millions of Gross Tons hauled per link per year from the FRA database (10^6 tons/yr)[9].
l_L = Link length from the FRA database (miles).
EF_{iRR} = Weighted Emission Factor for pollutant i per railroad RR (Eqn 1; tons/gal).
$RFCI_{RR}$ = Railroad Fuel Consumption Index per railroad RR (Eqn 2; gross ton-miles/gal).

Note that approximately 36% of Class I route miles in the United States are shared by more than one Class I carrier, a fraction that drops to 26% when neglecting track only shared between one Class I freight railroad and Amtrak. Accurately apportioning the specific fractions of tonnage (MGT) per carrier per link was considered, but after comparing likely worst-case areas, the difficultly of merging carrier-specific MGT with the aggregated FRA MGT dataset was considered too great considering the potential gain in accuracy. Where warranted, MGT data may be apportioned more accurately in the future.

Limitations, Conclusions, and Future Work

Rail-related emissions can be important components of emissions inventories used to support effective air quality management practices, at local, state, regional, and national levels. This line-haul inventory, as well as the companion Class I railyard inventory and Class II/III inventory, greatly improve our estimates of rail-related emissions. However, a systematic study of variability and uncertainty in line-haul locomotive emissions and activity, by fleets, locations, and through time, would give valuable information for identifying how to best improve this inventory as well provide an indication of how representative the inventory may be. An uncertainty study on the data used for this inventory, including the R-1 reported fuel use and the confidential link-level tonnage data, would also help in evaluating the quality of this inventory. Localized studies should also examine how shared tracks are apportioned between multiple carriers.

Early ERTAC Rail discussions concluded that link-level tonnage was the most important data to obtain, while other variables such as track grade and track speed could not be addressed at this time. ERTAC Rail calculated railroad-specific fleet-averaged emission factors rather than applying the estimated national average; however, it is recognized that emissions from individual engines are highly variable even within Tier categories depending on variables such as the specific locomotive model, operation cycle, and conditions of operation. Future evaluation of emission variability within Tiers and between certain types of operation and locations would also be valuable.

Emissions inventory preparation guidance from the U.S. EPA describes locomotive activity as relatively constant throughout the year (e.g. no daily, weekly, or seasonal variability); however, actual activity levels do vary seasonally and annual averaging may dilute or exaggerate concentrations during pollution episodes. ERTAC Rail and the Class I railroad community had some discussions addressing if incorporating more specific fleet mix or monthly or seasonal variation may be worthwhile, and these topics should be looked into further.

Finally, it is important to reiterate that the link-level MGT data maintained by the FRA is proprietary and can only be released to agencies/groups outside the FRA with the express permission of each Class I railroad. It is possible that one or more Class I railroads could withhold permission for access, but data for specialized studies may be provided if requested. This database can also be improved by better distinguishing between haulage and trackage rights, and by apportioning tonnage hauled on links to specific carriers.

We would like to thank the Class I Railroads and their representatives for their assistance and support in the development of this inventory.

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Appendix A: ERTAC Rail Data Workgroup

REPRESENTATIVE	ORGANIZATION
Matt Harrell	IL EPA
Michelle Bergin (Co-Chair) and Byeong Kim	GA EPD
Mark Janssen (Co-Chair)	LADCO
Julie McDill and Patrick Davis	MARAMA
Laurel Driver	US EPA OAQPS
Robert Fronczak	AAR
Steven Sullivan	ASLRRA
Rick Nath	CSX
David Seep and Lyle Staley	BNSF
Ken Roberge	CPR
Carl Akins and Peter Conlon	KCS
Erika Akkerman	CN
M. John Germer	UP
Brent Mason and Richard Russell	NS
Joanne Maxwell	Amtrak

Appendix B: Source and Year of Data Utilized for Each Inventory

Data	Year	Source
Class I Line-Haul		
Annual Line-Haul Fuel Use and Gross Ton-Miles	2007	STB R-1 Reports (CP data for D&H is for 2008.)
Line-haul fleet mix for emission factors	2008	Each Class I railroad
Link-level tonnage	2007	FRA confidential database
Class I Railyards (Switcher Locomotives)		
Annual Switcher Fuel Use	2008	R-1 Reports
Switcher fleet mix for emission factors	2008	Each Class I railroad
Link-level tonnage or Density Code (for activity estimate)	2007	FRA confidential database
Class II and III Locomotives		
Annual Total Fuel Use	2008	ASLRRA Annual Report (2008)
Track length and railroad	2008	ASLRRA Annual Report (2008)
Estimated fleet mix for emission factors		Discussions with ASLRRA and Class II and III representatives.

Appendix B

ERTAC Class II/III Line Haul Documentation

DRAFT

ERTAC – Class 2/3 Shapefile Documentation

13 Jul 2009

Introduction

This document outlines the methods and procedures used to compile a shapefile representing the links in the FRA 1:100,000 railroad dataset that are owned or operated by Class II and III railroad companies. It is important to note that there is a considerable amount of overlap between the Class II's and III's and the Class I and passenger railroads. Class II's and III's can operate on Class I or passenger rail links and vice versa. Although the final shapefile specifically represents Class II and III links, there are many Class I and passenger railroads represented as well.

Procedure

1. Started with all proprietary FRA links where "NET = 'M' and "STCNTYFIPS" <> ' ' (this definition query selects all active mainline links located within the United States).
2. Ran 12 queries, one for each ownership and trackage rights field, to select all links not associated with a Class I freight railroad or Amtrak and not containing a null value (e.g., "RROWNER1" <> 'AMTK' AND "RROWNER1" <> 'BNSF' AND "RROWNER1" <> 'CN' AND "RROWNER1" <> 'CPRS' AND "RROWNER1" <> 'CSXT' AND "RROWNER1" <> 'KCS' AND "RROWNER1" <> 'NS' AND "RROWNER1" <> 'UP' AND "RROWNER1" <> ' '). The first query was setup as a new selection. Each of the 11 subsequent queries were setup to add records to initial set of records. 26,261 links were selected and exported to a new shapefile.
3. Due to the multitude of railroad codes used to represent commuter rail operations across the country, additional processing was required to remove any links that were not operated by a Class II or III freight railroad. Each commuter railroad was queried out of the new shapefile and the links analyzed to eliminate all links where no Class II or III operations were occurring. The following commuter rail operations were evaluated: NJT (New Jersey Transit), MNCW (Metro-North Commuter Railroad), LI (Long Island Railroad), CDOT (Connecticut DOT), MBTA (Massachusetts Bay Transportation Authority), SEPA (Southeastern Pennsylvania Transportation Authority), MARC (Maryland Area Rail Commuter), VRE (Virginia Railway Express), MTRA (Northeastern Illinois Regional Commuter Railroad), CSS (Northern Indiana Commuter Transportation District), DART (Dallas Area Rapid Transit), SCRA (Southern California Regional Rail Authority – including also SCAX, LACM, LAPT, and LATC), TCRA (South Florida Regional Transportation Authority), PJPB (Caltrain), and ACE (Altamont Commuter Express).

Approximately 1581 links were identified with no Class II or III operations and were deleted from the Class 2/3 shapefile.

4. The remaining Class II and III links were then compared to the regional maps contained in the July-August issue of The Official Railway Guide to assess the completeness of the Class 2/3 shapefile. Six specific edits were made to the shapefile to correct the most glaring errors: 1) BMLP links deleted (Black Mesa & Lake Powell, an electric coal hauling railway in Arizona); 2) DSNG links deleted (Durango & Silverton steam tourist railroad in Colorado; 3) CIC haulage rights links on CN from Chicago to Omaha deleted; 4) DMIR links deleted (Duluth, Missabe & Iron Range, now owned and operated by CN in Minnesota; 5) EVWR's ex-CSXT links coded from Evansville, IN to Okawville, IL (Evansville Western Railroad); 6) INRD ex-CP links coded from Chicago, IL to Louisville, IN (Indiana Rail Road).
5. During the course of reviewing the FRA dataset, 555 "active" links were found to have no ownership or trackage rights codes. 1005 links have no codes listed in the 3 ownership fields. In most cases these links are very short and scattered across the country. Only the links representing the EVWR and INRD spanned large distances and were fixed. The other problem links were deemed to be insignificant. A listing of these links will be provided back to the FRA to assist with their coding in 1:100K railway shapefile.

Appendix C

ERTAC Rail Yard Documentation

DRAFT

ERTAC Rail Emissions Inventory
Part 2: Class I Railyard Switcher Locomotives

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Byeong Kim, GA Environmental Protection Division

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Air protection agencies from twenty-seven states, coordinated through the Eastern Regional Technical Advisory Committee (ERTAC) and headed by the Lake Michigan Air Directors Consortium (LADCO), identified a need to better quantify and characterize rail-related emissions inventories. Traditional locomotives largely utilize diesel engines, resulting in emissions of NO_x, diesel PM, hydrocarbons, greenhouse gases, and other pollutants. These emissions are sometimes concentrated in areas exceeding National Ambient Air Quality Standards. No cohesive nationwide railroad emission estimates are known to have been made previously. Inventory development methods for locomotive emissions estimates vary from state to state and, in general, lack the spatial or temporal resolution needed to support air quality modeling and planning [1-5].

The ERTAC Rail Subcommittee (ERTAC Rail) was established with active representatives from twelve member states, three regional planning offices, and the US EPA. The subcommittee's goals are to (1) standardize agencies' inventory development methods through a collaborative effort, (2) improve the quality of data received and the resulting emission inventories, and (3) reduce the administrative burden on railroad companies of providing data. With support from the Rail industry and assistance from the ERTAC Rail Data Workgroup (Appendix), ERTAC Rail has developed 3 inventories of locomotive emissions; from Class I line-haul, Shortline and Regional Railroads, and Class I railyard switchers, for the year 2008 (Table 1).

The Surface Transportation Board (STB) defines Class I Railroads as having had minimum carrier operating revenues of $401.4 million (USD) in 2008. There are 8 Class I Railroads operating in the United States (Table 2), about 12 Regional Railroads (Class II), and approximately 530 Class III Railroads (Shortlines). While categorized as a Class I Railroad, Amtrak was excluded from these inventories because of significant differences in equipment and operation characteristics. Line-haul locomotives travel long distances (e.g. between cities) while switcher locomotives largely operate in railyards, splitting and joining rail cars with varying destinations. Passenger and Commuter Rail (including Amtrak), industrial locomotives, and associated non-locomotive equipment are not included in these inventories.

Table 1. Summary of ERTAC Rail Inventories: U.S. Locomotive Emissions and Fuel Use for either 2007 or 2008*.

	Fuel Use** (gal/yr)	Emissions (tons/yr)					
		NO_x	$PM_{2.5}$	HC	SO_2	CO	NH_3
Class I*** line-haul	3,770,914,002	754,443	23,439	37,941	7,836	110,969	347
Class I switcher	300,492,223	73,741	2,024	4,824	619	9,152	27
Class II and III	157,800,000	51,367	1,163	1,897	357	5,058	16

*See Appendix B for a description of the year and source of data utilized for each inventory.
**Locomotive grade diesel
***Excluding Amtrak and including work train fuel use

Table 2. Class I Railroads and Reported Locomotive Fuel Use[7].

Class I Railroads*	R-1 Reported Locomotive Fuel Use (gal/yr)	
	Line-Haul (2007)**	Switcher (2008)
BNSF	1,393,874,954	52,497,057
Canadian National	93,830,751	12,290,022
Canadian Pacific***	50,320,233	4,594,067
CSX	514,687,186	53,717,674
Kansas City Southern	69,787,071	1,816,759
Norfolk Southern	463,267,278	32,317,375
Union Pacific	1,185,146,529	143,470,336
Total	**3,770,914,002**	**300,492,223**

* Excluding Amtrak
** Includes work trains
*** CP's line-haul fuel use values include 2008 data (rather than 2007) for their Delaware and Hudson subsidiary.

This paper documents the data sources and methodologies used for calculating the Class I switcher ("Railyard") inventory. Information on ERTAC Rail, Railroad participation, the Rail industry, and effects of rail on air quality are available elsewhere[6].

Method

Switcher locomotives are expected to be the single largest source of air emissions in railyards. Therefore, as a starting point for a comprehensive railyard inventory, a Class I switcher emission inventory was developed. It is assumed that estimates for yards of interest, associated equipment and activity, and smaller railroads could be refined later.

While ERTAC Rail represents states east of the Mississippi River, the railroad companies specified they wanted this effort to result in a consistent nationwide inventory. ERTAC Rail agreed to calculate emissions for all states when the data was available and when additional significant effort was not required. Because both the dataset of railyards and switcher fuel use was nationwide in scope, the resulting initial railyard inventory is a nationwide, 'top-down' derivation. However, railroad companies may have different levels and quality of data available, and may have interpreted some data requests differently. Also, states are requested to update yards they have detailed information on when possible, and a few states (i.e. California) have unique railroad operations and equipment. Therefore, data for some areas will be more accurate than for others, and locally-derived inventories may be more accurate.

This documentation describes development of the initial top-down inventory, which consisted of three main activities:

1. Locate Class I Railyards
2. Select/Calculate Emission Factors
3. Estimate Locomotive Activity
4. Improve Estimates

1. Locate Class I Railyards.

Identification and correct placement of railyards was an important first step, requiring a comprehensive electronic dataset. A confidential database was obtained from the Federal Railroad Administration (FRA) with permission from the Class I Railroads (FRA database). A similar public database compiled by the Bureau of Transportation Statistics is also available[7]. Data from this source will not match the confidential data exactly, but will be very similar. The FRA database has rail links (track lengths) individually identified as parts of specific railyards. While there may be discrepancies in how each railroad defined railyard links, this dataset appears to identify most Class I railyards in the U.S., and shows a high density of yards in the eastern states (Figure 1). The database gives length, up to 3 owners and 3 operators, and a Federal Density Code (explained below) for each railyard link.

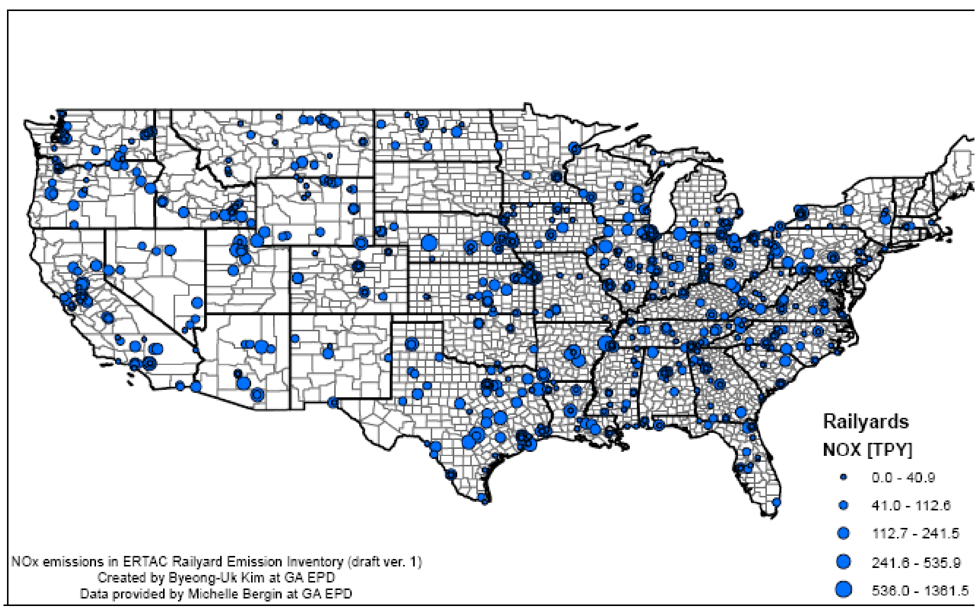

Figure 1. Class I Railyards in the United States and estimates of Annual NOx emissions from switcher locomotives (tons/yr in 2008).

2. Select/Calculate Emission Factors.

The EPA provides annual default emission factors based on characteristic operating cycles (‘duty cycles’) and the estimated nationwide fleet mix for both switcher and line-haul locomotives. However, switcher fleet mix is not uniform from company to company and, as can be seen in Figure 2, Class I railroad activity is highly regional.

As an alternative approach, ERTAC Rail requested each Class I rail company to provide a description of their switcher fleet mix based on Tier rating, which each company provided under a confidentiality agreement. An engine’s Tier determines allowable emission limits based on the year the engine was built (Table 3). While engine emissions are variable within Tier categories, this estimate likely provides a better regional estimate than the nationwide average. The company-specific systemwide fleet mix was used to calculate weighted average emissions factors for switchers operated by each Class I railroad.

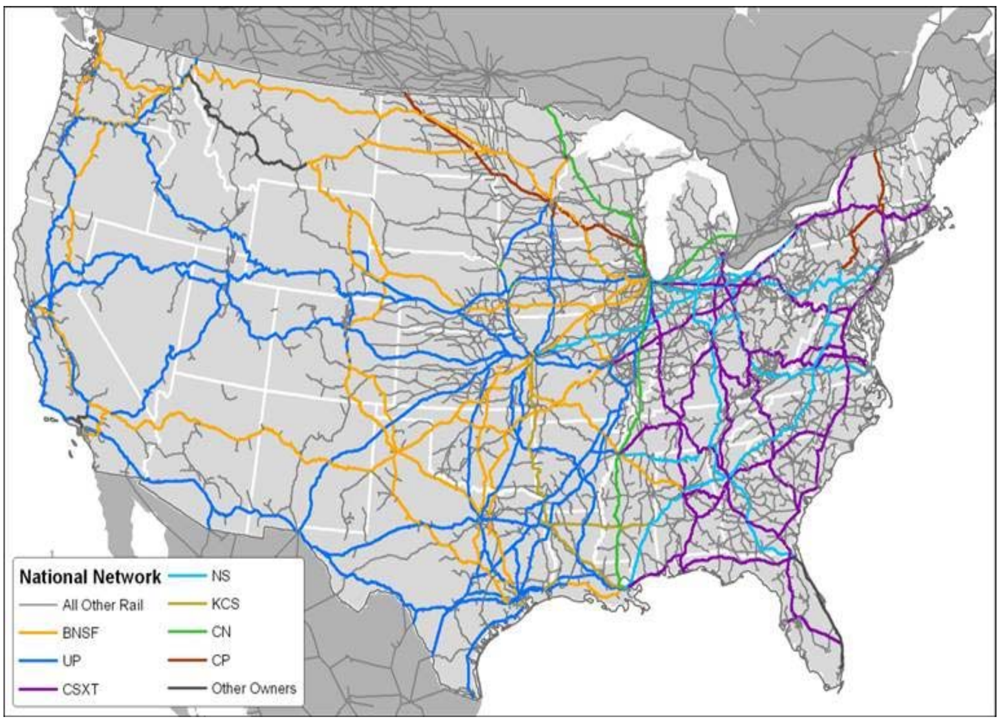

Figure 2. Class I Railroad Territories in the United States.

Table 3. EPA switcher locomotive emission factors by Tier, 1997 standards (grams/gal).

	PM_{10}	HC	NO_x	CO
Uncontrolled (pre-1973)	6.688	15.352	264.48	27.816
Tier 0 (1973-2001)	6.688	15.352	191.52	27.816
Tier 1 (2002-2004)	6.536	15.352	150.48	27.816
Tier 2 (2005 +)	2.888	7.752	110.96	27.816

Listed years apply to the year the engine was built. Table based on values from [8]. Note that the new standards released in 2008 did not apply to existing fleets in the year 2008.

For locomotives, $PM_{2.5}$ is assumed to be 97% of PM_{10} [8], and emission factors for SO_2 and NH_3 are 1.88 g/gal and 83.3 mg/gal respectively (add cites). Greenhouse gases are also estimated using emission factors shown in Table 4.

Table 4. EPA greenhouse gas emission factors for locomotive diesel fuel (grams/gal).

	CO_2	**N_2O**	**CH_4**
Locomotive diesel	1.015E4	0.26	0.80

Source: U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, EPA 430-R-07-002, Annex 3.2, (April 2007), web site: http://www.epa.gov/climatechange/emissions/usinventoryreport.html

These emission factors are based on a characteristic duty cycle for switchers which assumes operation over 24-hour per day 365 days per year. An evaluation of the effect of variability in railyards and switching duties on emissions would be useful for future inventories.

3. Estimate Locomotive Activity.

Class I railroads report total annual switcher locomotive fuel use to the STB, which is reported in publicly available 'R-1' reports (Table 2). There may be inconsistencies between railroads in how fuel use is estimated to be apportioned between line-haul and switcher locomotive use, and possibly in the total locomotive fuel use, so these values may be adjusted in the future. However, the use of these values provides a starting point for estimating total U.S. Class I locomotive-related emissions segregated by Class I carrier. The R-1 report was used by ERTAC for both the line-haul and switcher locomotive emissions inventories.

The next step for inventory development is to allocate switcher fuel use to each railyard. Two methods were applied, one that relies on publicly available line-haul activity (the 'Dencode' method), and the other using confidential line-haul activity (the 'MGT' method.) At this time, Norfolk Southern and Kansas City Southern have provided input for use of the MGT method and the Dencode method is applied for the other five railroads.

The Dencode Method – Publicly available data

Each link in both the publicly available BTS database and the confidential FRA database has a 'Federal Density Code' (Dencode) ranging from 1 to 7 assigned based on the cumulative annual freight tonnage hauled on the link (track). Total Switcher Fuel Use in each railyard Y (SFU_Y) is estimated as follows:

First the Switcher Activity Indicator per yard (SAI_Y) is estimated by multiplying the average dencode of the links identified as part of the same railyard by the sum of the length of the links for that railyard (Eqn 1).

$$SAI_Y = \sum(l_{nY} * FDC_{nY}) \qquad \text{Equation 1}$$

SAI_Y = Switcher Activity Indicator in Railyard Y

n_Y = number of links identified as part of railyard Y
l_{nY} = length of link n in miles
FDC_n = Federal Density Code (1 to 7) of link n

Next, this value is then weighted (SAI_Y') based on an ownership factor (OF) set between 0 and 1. The OF depends on the number of owners listed for each railyard: if there is one owner the OF is set to 1, if there are two owners the primary owner is set to 0.8 and the secondary is 0.2, and if there are 3 owners the primary is 0.6, the secondary is 0.2, and the tertiary is 0.1.

$SAI_Y' = OF_Y * SAI_Y$ Equation 2

Next, the SAI_Y' of all railyards belonging to a Class I railroad (RR) were summed, and the fraction of the railroads total SAI associated with each railyard was multiplied by the railroads total annual switcher fuel use reported in the R-1 (TFU_{RR}), resulting in the total Switcher Fuel Use for each railyard Y (Eqn 2).

$$SFU_Y = \frac{SAI_Y'}{\sum_{RR} SAI_Y'} * TFU_{RR}$$ Equation 3

SFU_Y = Switcher Fuel Use at railyard Y

Finally, the SFU_Y is multiplied by the emission factors described in the previous section to obtain annual switcher emissions at each railyard.

The MGT Method – Confidential data

Two railroads, Norfolk Southern and Kansas City Southern, provided confidential link-level tonnage information and weighting factors to correct skewed estimates to improve estimated switcher activity at important yards. Other railroads may also allow the use of this technique for their inventories in the future.

The MGT Method also uses the FRA database for railyard identification and link lengths. However, rather than using the average dencode per link, confidential annual gross tonnage (MGT) hauled per link in the railyard was used to calculate the railyard switcher activity (SAI_Y). This is calculated by replacing FDC_n in Equation 2 with link-specific tonnage MGT_n (Equation 4).

$$SAI_Y = \sum (l_{nY} * MGT_{nY})$$ Equation 4

SAI_Y = Switcher Activity Indicator in Railyard Y
n_Y = number of links identified as part of railyard Y

l_{nY} = length of link n in miles
MGT_{nY} = million gross tons on link n

This method provides a more refined comparison between railyards than the use of the 7-category dencodes; however, is more susceptible to errors for yards where tonnage is not correlated to switching activity. For example, a yard with large coal trains pulling through used for crews to change over would be assigned an overly high level of emissions for switching activity. To account for this, a discretionary Switching Activity Factor (SAF) was introduced to allow railroads to roughly weight yards with clearly higher or lower levels of switching activity than what results from the mathematical allocation. Therefore, SAI_Y is weighted based on both the ownership factor (OF) as well as the SAF (Equation 5). For example, a yard used for crew changes and not switching may have an SAF of 0, while a yard at a major interchange between cities may have an SAF of 3.

$$SAI_Y' = OF_Y * SAF_Y * SAI_Y \qquad \text{Equation 5}$$

Again, the SAI_Y' of all railyards belonging to a Class I railroad (RR) are summed, and the fraction of the railroads total SAI associated with each railyard was multiplied by the railroads total annual switcher fuel use reported in the R-1 (TFU_{RR}), resulting in the total Switcher Fuel Use for each railyard Y (Eqn 6).

$$SFU_Y = \frac{SAI_Y'}{\sum_{RR} SAI_Y'} * TFU_{RR} \qquad \text{Equation 6}$$

While the SAF allows estimates of yard-specfic emissions to be adjusted, the total level of emissions for each railroad, which is based on systemwide fuel use and systemwide emission factors, remains unchanged. The MGT method SFU_Y is also later multiplied by the emission factors described in the previous section to obtain annual switcher emissions at each railyard.

4. Improve estimates.

In addition to the Switching Activity Factor described above, direct input was also used to improve emission estimates for important railyards. Each Class I railroad provided an estimate of annual average switcher fuel use (generally much lower than the EPA default of 82,490 gal/yr) as well as the name, location, and number of operating switchers for railyards with 8 or more switchers operating in ozone or PM2.5 nonattainment areas. This data was used to overwrite the dencode or MGT derived emissions estimates for those railyards.

The difference in estimated fuel use for those railyards was re-allocated (added or removed) between the remaining railyards belonging to that Class I railroad. It is important to note that there are some discrepancies in how this data was reported for the large railyards by each railroad. For example, some railroads reported all switchers located at a railyard while others reported 'full time equivalent' switchers, meaning the number of switchers normalized to a full working cycle (24-hours per day year-round.) This process should be standardized for future inventory versions.

States also have the option of updating specific railyard emissions estimates. Because this inventory is derived 'top-down', local studies and familiarity with specific railyards is expected to provide better estimates, which can be used to adjust this inventory. Care must be taken to ensure the other railyard estimates are adjusted to account for increases or decreases in estimated fuel use per yard.

Limitations, Conclusions, and Future Work

What this ERTAC Rail railyard inventory does well is provide a comprehensive overview of where railyards are, who owns them, and gives a geographical allocation of switcher emissions bounded by what is reported as nationwide switcher fuel usage by the Class I railroads. These sources can be important for air quality management in nonattainment areas, as well as in regional analysis and for future transportation planning. This inventory will be useful for regional and some local modeling, helps identify where railyards need to be better characterized, and provides a strong foundation for future development of a meaningful nationwide Class I switcher emissions inventory.

There are important uncertainties associated with estimates from this method, including, but not limited to, the use of tonnage hauled as an indicator of the amount of switching activity, and, for a few of the railroads, how the amount of switcher fuel use was determined to be reported in the R-1. The R-1 reported values are currently under examination.

There is also likely significant variability in actual switching duty-cycles and, potentially, in the number of switchers operating at some railyards at different times of the year. 'Road-switching', or the use of what are considered switching locomotives to move between nearby yards, should be addressed in either this or the ERTAC line-haul inventory.

It must be noted that freight-related rail activity is not always routine and no annual emissions inventory will ever be able to capture the innate variability of the source. However, as other large emission sources are reduced, and if rail activity increases as expected, it is important to include our best estimates of these sources in air quality analysis. In the future, on-line data loggers and other tracking technologies, combined with ambient studies and detailed modeling, will hopefully provide more insight to the emissions of locomotives and other railyard sources.

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Appendix: ERTAC Rail Data Workgroup

REPRESENTATIVE	ORGANIZATION
Matt Harrell	IL EPA
Michelle Bergin (Co-Chair) and Byeong Kim	GA EPD
Mark Janssen (Co-Chair)	LADCO
Julie McDill and Patrick Davis	MARAMA
Laurel Driver	US EPA OAQPS
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M. John Germer	UP
Brent Mason and Richard Russell	NS
Joanne Maxwell	Amtrak

Appendix A-4

List of St. Louis County and St. Louis City Nonroad Emissions by SCC

Area	SCC	2008 CO Emissions (tons/year)
St. Louis County	2260001010	201.59
St. Louis County	2260001020	-
St. Louis County	2260001030	280.60
St. Louis County	2260001060	45.48
St. Louis County	2260002006	75.73
St. Louis County	2260002009	2.77
St. Louis County	2260002021	3.34
St. Louis County	2260002027	0.03
St. Louis County	2260002039	192.25
St. Louis County	2260002054	0.68
St. Louis County	2260003030	1.12
St. Louis County	2260003040	0.09
St. Louis County	2260004015	11.16
St. Louis County	2260004016	110.40
St. Louis County	2260004020	146.27
St. Louis County	2260004021	2,070.88
St. Louis County	2260004025	191.31
St. Louis County	2260004026	1,139.14
St. Louis County	2260004030	128.59
St. Louis County	2260004031	1,279.60
St. Louis County	2260004035	147.00
St. Louis County	2260004036	747.30
St. Louis County	2260004071	0.46
St. Louis County	2260005035	0.07
St. Louis County	2260006005	29.35
St. Louis County	2260006010	193.41
St. Louis County	2260006015	0.08
St. Louis County	2260006035	1.28
St. Louis County	2260007005	7.68
St. Louis County	2265001010	85.85
St. Louis County	2265001030	885.66
St. Louis County	2265001050	942.36
St. Louis County	2265001060	55.59
St. Louis County	2265002003	43.36
St. Louis County	2265002006	0.38
St. Louis County	2265002009	105.79
St. Louis County	2265002015	76.49
St. Louis County	2265002021	185.89
St. Louis County	2265002024	68.91
St. Louis County	2265002027	3.51
St. Louis County	2265002030	130.92
St. Louis County	2265002033	56.94
St. Louis County	2265002039	299.14
St. Louis County	2265002042	194.85
St. Louis County	2265002045	7.18

Area	SCC	2008 CO Emissions (tons/year)
St. Louis County	2265002054	19.22
St. Louis County	2265002057	9.27
St. Louis County	2265002060	19.45
St. Louis County	2265002066	100.33
St. Louis County	2265002072	53.81
St. Louis County	2265002078	29.74
St. Louis County	2265002081	8.90
St. Louis County	2265003010	118.36
St. Louis County	2265003020	253.53
St. Louis County	2265003030	77.92
St. Louis County	2265003040	188.58
St. Louis County	2265003050	8.50
St. Louis County	2265003060	4.43
St. Louis County	2265003070	13.89
St. Louis County	2265004010	3,203.78
St. Louis County	2265004011	4,790.28
St. Louis County	2265004015	269.26
St. Louis County	2265004016	2,783.47
St. Louis County	2265004025	17.54
St. Louis County	2265004026	106.24
St. Louis County	2265004030	33.52
St. Louis County	2265004031	3,522.30
St. Louis County	2265004035	384.09
St. Louis County	2265004036	1,952.52
St. Louis County	2265004040	522.88
St. Louis County	2265004041	448.08
St. Louis County	2265004046	639.08
St. Louis County	2265004051	323.11
St. Louis County	2265004055	6,970.00
St. Louis County	2265004056	6,088.28
St. Louis County	2265004066	762.57
St. Louis County	2265004071	19,082.16
St. Louis County	2265004075	304.00
St. Louis County	2265004076	821.05
St. Louis County	2265005010	0.25
St. Louis County	2265005015	0.54
St. Louis County	2265005020	0.00
St. Louis County	2265005025	0.36
St. Louis County	2265005030	0.24
St. Louis County	2265005035	2.48
St. Louis County	2265005040	7.00
St. Louis County	2265005045	0.57
St. Louis County	2265005055	1.08
St. Louis County	2265005060	0.68
St. Louis County	2265006005	9,140.97

Area	SCC	2008 CO Emissions (tons/year)
St. Louis County	2265006010	1,856.31
St. Louis County	2265006015	809.73
St. Louis County	2265006025	2,066.08
St. Louis County	2265006030	3,894.54
St. Louis County	2265006035	158.28
St. Louis County	2265007010	15.73
St. Louis County	2265007015	0.13
St. Louis County	2265008005	76.64
St. Louis County	2265010010	33.50
St. Louis County	2267001060	0.56
St. Louis County	2267002003	1.67
St. Louis County	2267002015	2.52
St. Louis County	2267002021	0.48
St. Louis County	2267002024	0.28
St. Louis County	2267002030	5.19
St. Louis County	2267002033	1.92
St. Louis County	2267002039	3.86
St. Louis County	2267002045	1.97
St. Louis County	2267002054	0.33
St. Louis County	2267002057	3.43
St. Louis County	2267002060	8.06
St. Louis County	2267002066	0.82
St. Louis County	2267002072	7.20
St. Louis County	2267002081	2.99
St. Louis County	2267003010	39.88
St. Louis County	2267003020	3,400.08
St. Louis County	2267003030	22.91
St. Louis County	2267003040	7.49
St. Louis County	2267003050	2.14
St. Louis County	2267003070	12.77
St. Louis County	2267004066	63.21
St. Louis County	2267005055	0.00
St. Louis County	2267005060	0.00
St. Louis County	2267006005	130.87
St. Louis County	2267006010	29.26
St. Louis County	2267006015	34.31
St. Louis County	2267006025	61.57
St. Louis County	2267006030	0.84
St. Louis County	2267006035	0.51
St. Louis County	2267008005	20.76
St. Louis County	2268002081	0.12
St. Louis County	2268003020	242.20
St. Louis County	2268003030	0.26
St. Louis County	2268003040	0.18
St. Louis County	2268003060	0.43

Area	SCC	2008 CO Emissions (tons/year)
St. Louis County	2268003070	0.94
St. Louis County	2268005055	0.00
St. Louis County	2268005060	0.03
St. Louis County	2268006005	39.53
St. Louis County	2268006010	1.96
St. Louis County	2268006015	2.65
St. Louis County	2268006020	18.62
St. Louis County	2268006035	-
St. Louis County	2268010010	2.04
St. Louis County	2270001060	1.62
St. Louis County	2270002003	14.60
St. Louis County	2270002006	0.05
St. Louis County	2270002009	0.78
St. Louis County	2270002015	43.32
St. Louis County	2270002018	39.51
St. Louis County	2270002021	2.77
St. Louis County	2270002024	2.21
St. Louis County	2270002027	5.68
St. Louis County	2270002030	27.41
St. Louis County	2270002033	17.40
St. Louis County	2270002036	119.52
St. Louis County	2270002039	2.07
St. Louis County	2270002042	0.87
St. Louis County	2270002045	21.91
St. Louis County	2270002048	26.57
St. Louis County	2270002051	99.30
St. Louis County	2270002054	5.27
St. Louis County	2270002057	69.69
St. Louis County	2270002060	166.51
St. Louis County	2270002066	252.07
St. Louis County	2270002069	140.57
St. Louis County	2270002072	219.31
St. Louis County	2270002075	20.22
St. Louis County	2270002078	0.66
St. Louis County	2270002081	20.70
St. Louis County	2270003010	10.87
St. Louis County	2270003020	67.13
St. Louis County	2270003030	15.90
St. Louis County	2270003040	17.36
St. Louis County	2270003050	1.88
St. Louis County	2270003060	68.10
St. Louis County	2270003070	24.84
St. Louis County	2270004031	0.01
St. Louis County	2270004036	1.36
St. Louis County	2270004046	49.81

Area	SCC	2008 CO Emissions (tons/year)
St. Louis County	2270004056	10.48
St. Louis County	2270004066	57.34
St. Louis County	2270004071	4.94
St. Louis County	2270004076	0.20
St. Louis County	2270005010	0.00
St. Louis County	2270005015	12.01
St. Louis County	2270005020	0.90
St. Louis County	2270005025	0.01
St. Louis County	2270005030	0.00
St. Louis County	2270005035	0.09
St. Louis County	2270005040	0.00
St. Louis County	2270005045	0.10
St. Louis County	2270005055	0.25
St. Louis County	2270005060	0.12
St. Louis County	2270006005	91.88
St. Louis County	2270006010	21.71
St. Louis County	2270006015	47.20
St. Louis County	2270006020	-
St. Louis County	2270006025	72.41
St. Louis County	2270006030	2.74
St. Louis County	2270006035	2.06
St. Louis County	2270007010	-
St. Louis County	2270007015	1.56
St. Louis County	2270008005	85.78
St. Louis County	2270009010	-
St. Louis County	2270010010	0.95
St. Louis County	2282005010	562.87
St. Louis County	2282005015	241.18
St. Louis County	2282010005	386.17
St. Louis County	2282020005	3.66
St. Louis County	2282020010	0.04
St. Louis County	2285002015	2.33
St. Louis County	2285004015	4.47
St. Louis County	2285006015	0.03
St. Louis County Total		**89,513.99**
St. Louis City	2260001010	-
St. Louis City	2260001020	-
St. Louis City	2260001030	-
St. Louis City	2260001060	-
St. Louis City	2260002006	-
St. Louis City	2260002009	-
St. Louis City	2260002021	-
St. Louis City	2260002027	-
St. Louis City	2260002039	-
St. Louis City	2260002054	-

Area	SCC	2008 CO Emissions (tons/year)
St. Louis City	2260003030	0.50
St. Louis City	2260003040	0.04
St. Louis City	2260004015	4.55
St. Louis City	2260004016	5.92
St. Louis City	2260004020	59.63
St. Louis City	2260004021	111.05
St. Louis City	2260004025	78.00
St. Louis City	2260004026	61.08
St. Louis City	2260004030	52.43
St. Louis City	2260004031	68.62
St. Louis City	2260004035	59.93
St. Louis City	2260004036	40.07
St. Louis City	2260004071	0.02
St. Louis City	2260005035	-
St. Louis City	2260006005	10.22
St. Louis City	2260006010	67.33
St. Louis City	2260006015	0.03
St. Louis City	2260006035	0.45
St. Louis City	2260007005	-
St. Louis City	2265001010	-
St. Louis City	2265001030	-
St. Louis City	2265001050	118.00
St. Louis City	2265001060	-
St. Louis City	2265002003	-
St. Louis City	2265002006	-
St. Louis City	2265002009	-
St. Louis City	2265002015	-
St. Louis City	2265002021	-
St. Louis City	2265002024	-
St. Louis City	2265002027	-
St. Louis City	2265002030	-
St. Louis City	2265002033	-
St. Louis City	2265002039	-
St. Louis City	2265002042	-
St. Louis City	2265002045	-
St. Louis City	2265002054	-
St. Louis City	2265002057	-
St. Louis City	2265002060	-
St. Louis City	2265002066	-
St. Louis City	2265002072	-
St. Louis City	2265002078	-
St. Louis City	2265002081	-
St. Louis City	2265003010	52.70
St. Louis City	2265003020	112.89
St. Louis City	2265003030	34.70

Area	SCC	2008 CO Emissions (tons/year)
St. Louis City	2265003040	83.97
St. Louis City	2265003050	3.79
St. Louis City	2265003060	1.52
St. Louis City	2265003070	6.18
St. Louis City	2265004010	1,308.59
St. Louis City	2265004011	257.34
St. Louis City	2265004015	109.98
St. Louis City	2265004016	149.53
St. Louis City	2265004025	7.17
St. Louis City	2265004026	5.71
St. Louis City	2265004030	13.69
St. Louis City	2265004031	189.22
St. Louis City	2265004035	156.74
St. Louis City	2265004036	104.80
St. Louis City	2265004040	213.57
St. Louis City	2265004041	24.07
St. Louis City	2265004046	34.33
St. Louis City	2265004051	17.36
St. Louis City	2265004055	2,846.91
St. Louis City	2265004056	327.07
St. Louis City	2265004066	40.97
St. Louis City	2265004071	1,025.13
St. Louis City	2265004075	124.17
St. Louis City	2265004076	44.11
St. Louis City	2265005010	-
St. Louis City	2265005015	-
St. Louis City	2265005020	-
St. Louis City	2265005025	-
St. Louis City	2265005030	-
St. Louis City	2265005035	-
St. Louis City	2265005040	-
St. Louis City	2265005045	-
St. Louis City	2265005055	-
St. Louis City	2265005060	-
St. Louis City	2265006005	3,186.44
St. Louis City	2265006010	647.09
St. Louis City	2265006015	282.26
St. Louis City	2265006025	720.21
St. Louis City	2265006030	1,357.59
St. Louis City	2265006035	55.18
St. Louis City	2265007010	-
St. Louis City	2265007015	-
St. Louis City	2265008005	-
St. Louis City	2265010010	-
St. Louis City	2267001060	-

Area	SCC	2008 CO Emissions (tons/year)
St. Louis City	2267002003	-
St. Louis City	2267002015	-
St. Louis City	2267002021	-
St. Louis City	2267002024	-
St. Louis City	2267002030	-
St. Louis City	2267002033	-
St. Louis City	2267002039	-
St. Louis City	2267002045	-
St. Louis City	2267002054	-
St. Louis City	2267002057	-
St. Louis City	2267002060	-
St. Louis City	2267002066	-
St. Louis City	2267002072	-
St. Louis City	2267002081	-
St. Louis City	2267003010	17.73
St. Louis City	2267003020	1,511.71
St. Louis City	2267003030	10.19
St. Louis City	2267003040	3.33
St. Louis City	2267003050	0.95
St. Louis City	2267003070	5.68
St. Louis City	2267004066	3.39
St. Louis City	2267005055	-
St. Louis City	2267005060	-
St. Louis City	2267006005	45.56
St. Louis City	2267006010	10.19
St. Louis City	2267006015	11.94
St. Louis City	2267006025	21.43
St. Louis City	2267006030	0.29
St. Louis City	2267006035	0.18
St. Louis City	2267008005	-
St. Louis City	2268002081	-
St. Louis City	2268003020	107.69
St. Louis City	2268003030	0.12
St. Louis City	2268003040	0.08
St. Louis City	2268003060	0.15
St. Louis City	2268003070	0.42
St. Louis City	2268005055	-
St. Louis City	2268005060	-
St. Louis City	2268006005	13.76
St. Louis City	2268006010	0.68
St. Louis City	2268006015	0.92
St. Louis City	2268006020	6.48
St. Louis City	2268006035	-
St. Louis City	2268010010	-
St. Louis City	2270001060	-

Area	SCC	2008 CO Emissions (tons/year)
St. Louis City	2270002003	-
St. Louis City	2270002006	-
St. Louis City	2270002009	-
St. Louis City	2270002015	-
St. Louis City	2270002018	-
St. Louis City	2270002021	-
St. Louis City	2270002024	-
St. Louis City	2270002027	-
St. Louis City	2270002030	-
St. Louis City	2270002033	-
St. Louis City	2270002036	-
St. Louis City	2270002039	-
St. Louis City	2270002042	-
St. Louis City	2270002045	-
St. Louis City	2270002048	-
St. Louis City	2270002051	-
St. Louis City	2270002054	-
St. Louis City	2270002057	-
St. Louis City	2270002060	-
St. Louis City	2270002066	-
St. Louis City	2270002069	-
St. Louis City	2270002072	-
St. Louis City	2270002075	-
St. Louis City	2270002078	-
St. Louis City	2270002081	-
St. Louis City	2270003010	4.83
St. Louis City	2270003020	29.84
St. Louis City	2270003030	7.07
St. Louis City	2270003040	7.72
St. Louis City	2270003050	0.83
St. Louis City	2270003060	23.30
St. Louis City	2270003070	11.05
St. Louis City	2270004031	0.00
St. Louis City	2270004036	0.07
St. Louis City	2270004046	2.67
St. Louis City	2270004056	0.56
St. Louis City	2270004066	3.07
St. Louis City	2270004071	0.26
St. Louis City	2270004076	0.01
St. Louis City	2270005010	-
St. Louis City	2270005015	-
St. Louis City	2270005020	-
St. Louis City	2270005025	-
St. Louis City	2270005030	-
St. Louis City	2270005035	-

Area	SCC	2008 CO Emissions (tons/year)
St. Louis City	2270005040	-
St. Louis City	2270005045	-
St. Louis City	2270005055	-
St. Louis City	2270005060	-
St. Louis City	2270006005	31.98
St. Louis City	2270006010	7.56
St. Louis City	2270006015	16.43
St. Louis City	2270006020	-
St. Louis City	2270006025	25.21
St. Louis City	2270006030	0.95
St. Louis City	2270006035	0.72
St. Louis City	2270007010	-
St. Louis City	2270007015	-
St. Louis City	2270008005	-
St. Louis City	2270009010	-
St. Louis City	2270010010	-
St. Louis City	2282005010	151.01
St. Louis City	2282005015	64.71
St. Louis City	2282010005	103.83
St. Louis City	2282020005	0.98
St. Louis City	2282020010	0.01
St. Louis City	2285002015	2.12
St. Louis City	2285004015	4.07
St. Louis City	2285006015	0.03
St. Louis City Total		**16,556.63**
Combined Total for St. Louis County and St. Louis City		**106,070.62**

Appendix A-5

Nonpoint Industrial and Commercial/Institutional (ICI) Fuel Combustion Category Documentation

AREA COMBUSTION SOURCE EMISSIONS INVENTORY IMPROVEMENT METHODOLOGY

TECHNICAL MEMORANDUM

Contract No. 07-0901-RPO-036

March 20, 2009

Prepared for:

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A. INTRODUCTION

The objective of this project is to estimate area source emissions from Industrial and Commercial/Institutional (ICI) fuel combustion for the CENRAP region, which encompasses the States and tribal areas of Arkansas, Iowa, Kansas, Louisiana, Minnesota, Missouri, Nebraska, Oklahoma, and Texas. This project will result in the development of a set of revised 2002 ICI area source emission inventories for sulfur dioxide (SO_2), nitrogen oxides (NO_x), non-methane volatile organic compounds (VOCs), particulate matter (specifically, PM_{10} and primary/direct $PM_{2.5}$), ammonia (NH_3), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The emission inventories will be developed at the county level and will provide emissions for the following time periods: annual; monthly; and average weekly, weekday, and weekend day emissions for each month.

This technical memorandum is one of two components for documenting the methodology that E.H. Pechan & Associates, Inc. (Pechan) will follow in preparing CENRAP's 2002 ICI area source emissions inventory. The second component is a set of Microsoft® Excel workbook templates that Pechan will use to implement the methodology described in this document. This memorandum is organized into four sections: this section (Introduction), Section B (Methodology) , which describes the emission estimation methodology, Section C (Calculation Templates), which summarizes the content of the calculation templates, and Section D (References), which identifies the information sources that were consulted in preparing this document.

B. METHODOLOGY

This section documents the emission inventory development methodology that Pechan will use to prepare an ICI combustion area source emission inventory for the CENRAP States. Table 1 identifies the source classification codes (SCCs) for which Pechan plans to prepare ICI combustion area source emission estimates. It is important to note that some of these SCCs may not ultimately appear in each CENRAP State's inventory. If it is determined that all of an individual State's consumption of a particular fuel is already accounted for in the State's nonroad and/or point source inventory, then the SCC for that fuel will not be included in the area source inventory for that State.

The key data inputs in the emissions estimation methodology are:

1. Total Industrial and total Commercial/Institutional energy consumption by fuel type and CENRAP State for the year 2002;
2. Industrial energy consumption used for non-fuel purposes by fuel type and State in 2002;
3. ICI distillate fuel and liquefied petroleum gas (LPG) consumption for nonroad sources by State in year 2002;
4. ICI energy consumption by fuel type for point sources by CENRAP State in year 2002;
5. Emission factors relating emission rates to volume of energy consumed by fuel type for the ICI sectors;
6. Sulfur content of coal consumed in the ICI sectors by State in year 2002;

Table 1. ICI Combustion Area Source Classification Codes

SCC	DESCRIPTION
2102001000	Stationary Source Fuel Combustion; Industrial; Anthracite Coal; Total: All Boiler Types
2102002000	Stationary Source Fuel Combustion; Industrial; Bituminous/Subbituminous Coal; Total: All Boiler Types
2102004000	Stationary Source Fuel Combustion; Industrial; Distillate Oil; Total: Boilers and IC Engines
2102005000	Stationary Source Fuel Combustion; Industrial; Residual Oil; Total: All Boiler Types
2102006000	Stationary Source Fuel Combustion; Industrial; Natural Gas; Total: Boilers and IC Engines
2102007000	Stationary Source Fuel Combustion; Industrial; Liquid Petroleum Gas; Total: All Boiler Types
2102008000	Stationary Source Fuel Combustion; Industrial; Wood; Total: All Boiler Types
2102011000	Stationary Source Fuel Combustion; Industrial; Kerosene; Total: All Boiler Types
2103001000	Stationary Source Fuel Combustion; Commercial/Institutional; Anthracite Coal; Total: All Boiler Types
2103002000	Stationary Source Fuel Combustion; Commercial/Institutional; Bituminous/Subbituminous Coal; Total: All Boiler Types
2103004000	Stationary Source Fuel Combustion; Commercial/Institutional; Distillate Oil; Total: Boilers and IC Engines
2103005000	Stationary Source Fuel Combustion; Commercial/Institutional; Residual Oil; Total: All Boiler Types
2103006000	Stationary Source Fuel Combustion; Commercial/Institutional; Natural Gas; Total: Boilers and IC Engines
2103007000	Stationary Source Fuel Combustion; Commercial/Institutional; Liquid Petroleum Gas; Total: All Combustor Types
2103008000	Stationary Source Fuel Combustion; Commercial/Institutional; Wood; Total: All Boiler Types
2103011000	Stationary Source Fuel Combustion; Commercial/Institutional; Kerosene; Total: All Combustor Types

7. County-level employment in the ICI sectors by State for the year 2002; and
8. Temporal allocation data for estimating the proportion of annual fuel combusted by month, as well as data for estimating the volume of fuel combusted in each month for the following time-frames: average week, average week day; and average weekend day.

The following sections describe the methodology/data source(s) for developing each of these data inputs. The following identifies the planned source(s) of information for each of these data elements. In selecting the information sources for each of these data elements, Pechan evaluated the representativeness and level of confidence criteria identified in the Quality Assurance Project Plan (QAPP) for this project. For example, information sources that provide data specific to the source category/geography/inventory period were selected over those that are less specific.

1. Total ICI Energy Consumption

For total Industrial and total Commercial/Institutional energy consumption by fuel type/State, Pechan will use the same source that EPA uses in developing ICI combustion emission estimates for the National Emissions Inventory (NEI) – the Energy Information Administration (EIA)'s State Energy Data System (SEDS) (EIA, 2009a). The SEDS reports total energy consumption estimates by sector, State, fuel type, and year. To facilitate use with the criteria pollutant and GHG emission factors, Pechan will compile the SEDS energy consumption data in both sets of units provided by the SEDS: physical units and British thermal units (Btus).

2. Non-Fuel Energy Consumption

Some Industrial sector energy is consumed for non-fuel purposes. For example, natural gas is used as a feedstock in chemical manufacturing plants and to make nitrogenous fertilizer, and LPG is used to create intermediate products that are made into plastics. To estimate the volume of fuel that is associated with ICI combustion, it is necessary to subtract the volume of fuel consumption for non-energy uses from the volume of total fuel consumption. The EPA's State Inventory Tool (SIT) provides national defaults representing the percentage of total Industrial fuel consumption from non-energy uses.[1] These default values have an additional limitation beyond their lack of geographic detail - they represent the EIA's definition of the Industrial sector, which includes fuel use that is accounted for in other inventory source categories. In particular, the EIA Industrial sector includes fuel consumption from Farm, Mining, Construction, and Commercial sectors that is accounted for in the nonroad inventory. Because of these limitations, Pechan plans to use regional non-fuel use percentages computed from energy consumption data from the EIA's *2002 Manufacturing Energy Consumption Survey* (MECS) for all fuel types except coal (EIA, 2007). There are two reasons why MECS provides a more representative data set for use in this study: (1) MECS provides data specific to the regions of interest; and (2) MECS focuses solely on the Manufacturing sector. The latter characteristic is particularly important for fuel types which consume significant amounts of non-Manufacturing sector energy that is already included elsewhere (e.g., distillate fuel used by the Construction sector, which is included in the nonroad inventory). The MECS non-fuel consumption data treat

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[1] Although the SIT also develops CO_2 emission estimates associated with non-fuel energy use, such estimates are not developed here because they are not associated with industrial fuel combustion.

coal that is used to produce coke as a feedstock. However, available data indicate that none of the CENRAP States produce coke (Pechan, 2006). In addition, the 2002 MECS data treat "synthetic coal" that is ultimately combusted as regular coal, as a non-fuel (feedstock) use. Because of these data limitations, Pechan contacted EIA for assistance in obtaining a reasonable estimate of the percentage of non-coking coal that is used for non-fuel purposes (treating "synthetic coal" as a fuel use). Based on the EIA's estimate that 5-10 percent of 2002 non-coke coal was used for non-fuel purposes, Pechan plans to assume that 7 percent of CENRAP Industrial sector coal consumption is for non-fuel purposes (Lorenz, 2009).

Table 2 presents the available non-fuel use percentages by type of energy. It was not possible to develop percentages by region for each fuel type because some regional MECS data are withheld. For this study, Pechan plans to use the most geographic-specific data reported in Table 2. States are encouraged to provide available State-specific estimates to replace the defaults below.

Table 2. Industrial Sector Energy Consumption from Non-Fuel Uses

	2002 MECS % Energy Consumption from Non-Fuel Use			
Energy Type	**Midwest**	**South**	**Midwest+South**	**National**
Residual	not available	not available	25%	17%
Distillate	not available	not available	9%	7%
Natural Gas	6%	15%	12%	10%
LPG/NGL	88%	98%	97%	97%
Coal	not available	not available	not available	7%

Sources: EIA, 2007 and Lorenz, 2009.
Midwest region includes Iowa, Kansas, Minnesota, Missouri, and Nebraska.
South region includes Arkansas, Louisiana, Oklahoma, and Texas.

3. Nonroad Source Energy Consumption

To avoid double-counting with the nonroad inventory, it is necessary to subtract 2002 year diesel and LPG consumption estimates for Industrial, Farm, Logging, Mining, and Construction sector nonroad equipment. For the Commercial sector SEDS data, it is necessary to subtract 2002 year diesel and LPG consumption for Commercial sector nonroad equipment. Pechan plans to run the NONROAD model for 2002 for the CENRAP States to obtain State-level diesel and LPG consumption estimates to perform these subtractions. Table 3 identifies the SCCs for which Pechan will compile NONROAD fuel consumption estimates.

Table 3. Nonroad Sector Subtraction SCCs

SCC	Description_2	Description_3	Description_4
Industrial Sector-Distillate			
2270000000	Off-highway Vehicle Diesel	Compression Ignition Equipment except Rail and Marine	Total
2270001000	Off-highway Vehicle Diesel	Recreational Equipment	Total
2270001010	Off-highway Vehicle Diesel	Recreational Equipment	Motorcycles: Off-road
2270001020	Off-highway Vehicle Diesel	Recreational Equipment	Snowmobiles
2270001030	Off-highway Vehicle Diesel	Recreational Equipment	All Terrain Vehicles
2270001040	Off-highway Vehicle Diesel	Recreational Equipment	Minibikes
2270001050	Off-highway Vehicle Diesel	Recreational Equipment	Golf Carts
2270001060	Off-highway Vehicle Diesel	Recreational Equipment	Specialty Vehicles/Carts
2270002000	Off-highway Vehicle Diesel	Construction and Mining Equipment	Total
2270002003	Off-highway Vehicle Diesel	Construction and Mining Equipment	Pavers
2270002006	Off-highway Vehicle Diesel	Construction and Mining Equipment	Tampers/Rammers
2270002009	Off-highway Vehicle Diesel	Construction and Mining Equipment	Plate Compactors
2270002012	Off-highway Vehicle Diesel	Construction and Mining Equipment	Concrete Pavers
2270002015	Off-highway Vehicle Diesel	Construction and Mining Equipment	Rollers
2270002018	Off-highway Vehicle Diesel	Construction and Mining Equipment	Scrapers
2270002021	Off-highway Vehicle Diesel	Construction and Mining Equipment	Paving Equipment
2270002024	Off-highway Vehicle Diesel	Construction and Mining Equipment	Surfacing Equipment
2270002027	Off-highway Vehicle Diesel	Construction and Mining Equipment	Signal Boards/Light Plants
2270002030	Off-highway Vehicle Diesel	Construction and Mining Equipment	Trenchers
2270002033	Off-highway Vehicle Diesel	Construction and Mining Equipment	Bore/Drill Rigs
2270002036	Off-highway Vehicle Diesel	Construction and Mining Equipment	Excavators
2270002039	Off-highway Vehicle Diesel	Construction and Mining Equipment	Concrete/Industrial Saws
2270002042	Off-highway Vehicle Diesel	Construction and Mining Equipment	Cement and Mortar Mixers
2270002045	Off-highway Vehicle Diesel	Construction and Mining Equipment	Cranes
2270002048	Off-highway Vehicle Diesel	Construction and Mining Equipment	Graders

SCC	Description_2	Description_3	Description_4
2270002051	Off-highway Vehicle Diesel	Construction and Mining Equipment	Off-Highway Trucks
2270002054	Off-highway Vehicle Diesel	Construction and Mining Equipment	Crushing/Processing Equipment
2270002057	Off-highway Vehicle Diesel	Construction and Mining Equipment	Rough Terrain Forklifts
2270002060	Off-highway Vehicle Diesel	Construction and Mining Equipment	Rubber Tired Loaders
2270002063	Off-highway Vehicle Diesel	Construction and Mining Equipment	Rubber Tire Tractor/Dozers
2270002066	Off-highway Vehicle Diesel	Construction and Mining Equipment	Tractors/Loaders/Backhoes
2270002069	Off-highway Vehicle Diesel	Construction and Mining Equipment	Crawler Tractor/Dozers
2270002072	Off-highway Vehicle Diesel	Construction and Mining Equipment	Skid Steer Loaders
2270002075	Off-highway Vehicle Diesel	Construction and Mining Equipment	Off-Highway Tractors
2270002078	Off-highway Vehicle Diesel	Construction and Mining Equipment	Dumpers/Tenders
2270002081	Off-highway Vehicle Diesel	Construction and Mining Equipment	Other Construction Equipment
2270003000	Off-highway Vehicle Diesel	Industrial Equipment	Total
2270003010	Off-highway Vehicle Diesel	Industrial Equipment	Aerial Lifts
2270003020	Off-highway Vehicle Diesel	Industrial Equipment	Forklifts
2270003030	Off-highway Vehicle Diesel	Industrial Equipment	Sweepers/Scrubbers
2270003040	Off-highway Vehicle Diesel	Industrial Equipment	Other General Industrial Equipment
2270003050	Off-highway Vehicle Diesel	Industrial Equipment	Other Material Handling Equipment
2270003060	Off-highway Vehicle Diesel	Industrial Equipment	AC/Refrigeration
2270003070	Off-highway Vehicle Diesel	Industrial Equipment	Terminal Tractors
2270005000	Off-highway Vehicle Diesel	Agricultural Equipment	Total
2270005010	Off-highway Vehicle Diesel	Agricultural Equipment	2-Wheel Tractors
2270005015	Off-highway Vehicle Diesel	Agricultural Equipment	Agricultural Tractors
2270005020	Off-highway Vehicle Diesel	Agricultural Equipment	Combines
2270005025	Off-highway Vehicle Diesel	Agricultural Equipment	Balers
2270005030	Off-highway Vehicle Diesel	Agricultural Equipment	Agricultural Mowers
2270005035	Off-highway Vehicle Diesel	Agricultural Equipment	Sprayers
2270005040	Off-highway Vehicle Diesel	Agricultural Equipment	Tillers > 6 HP
2270005045	Off-highway Vehicle Diesel	Agricultural Equipment	Swathers
2270005050	Off-highway Vehicle Diesel	Agricultural Equipment	Hydro-power Units

SCC	Description_2	Description_3	Description_4
2270005055	Off-highway Vehicle Diesel	Agricultural Equipment	Other Agricultural Equipment
2270005060	Off-highway Vehicle Diesel	Agricultural Equipment	Irrigation Sets
2270007000	Off-highway Vehicle Diesel	Logging Equipment	Total
2270007005	Off-highway Vehicle Diesel	Logging Equipment	Chain Saws > 6 HP
2270007010	Off-highway Vehicle Diesel	Logging Equipment	Shredders > 6HP
2270007015	Off-highway Vehicle Diesel	Logging Equipment	Forest Eqp – Fellers/Bunch/Skidder
2270007020	Off-highway Vehicle Diesel	Logging Equipment	Fellers/Bunchers ** (see 22-70-007-015)
2270009000	Off-highway Vehicle Diesel	Underground Mining Equipment	All
2270009010	Off-highway Vehicle Diesel	Underground Mining Equipment	Other Underground Mining Equipment
2270010000	Off-highway Vehicle Diesel	Industrial Equipment	All
2270010010	Off-highway Vehicle Diesel	Industrial Equipment	Other Oil Field Equipment
Industrial Sector-LPG			
2267002000	LPG	Construction and Mining Equipment	All
2267002003	LPG	Construction and Mining Equipment	Pavers
2267002006	LPG	Construction and Mining Equipment	Tampers/Rammers
2267002009	LPG	Construction and Mining Equipment	Plate Compactors
2267002015	LPG	Construction and Mining Equipment	Rollers
2267002018	LPG	Construction and Mining Equipment	Scrapers
2267002021	LPG	Construction and Mining Equipment	Paving Equipment
2267002024	LPG	Construction and Mining Equipment	Surfacing Equipment
2267002027	LPG	Construction and Mining Equipment	Signal Boards/Light Plants
2267002030	LPG	Construction and Mining Equipment	Trenchers
2267002033	LPG	Construction and Mining Equipment	Bore/Drill Rigs
2267002036	LPG	Construction and Mining Equipment	Excavators
2267002039	LPG	Construction and Mining Equipment	Concrete/Industrial Saws
2267002042	LPG	Construction and Mining Equipment	Cement and Mortar Mixers
2267002045	LPG	Construction and Mining Equipment	Cranes
2267002048	LPG	Construction and Mining Equipment	Graders
2267002051	LPG	Construction and Mining Equipment	Off-highway Trucks

SCC	Description_2	Description_3	Description_4
2267002054	LPG	Construction and Mining Equipment	Crushing/Processing Equipment
2267002057	LPG	Construction and Mining Equipment	Rough Terrain Forklifts
2267002060	LPG	Construction and Mining Equipment	Rubber Tire Loaders
2267002063	LPG	Construction and Mining Equipment	Rubber Tire Tractors/Dozers
2267002066	LPG	Construction and Mining Equipment	Tractors/Loaders/Backhoes
2267002069	LPG	Construction and Mining Equipment	Crawler Tractor/Dozers
2267002072	LPG	Construction and Mining Equipment	Skid Steer Loaders
2267002075	LPG	Construction and Mining Equipment	Off-Highway Tractors
2267002078	LPG	Construction and Mining Equipment	Dumpers/Tenders
2267002081	LPG	Construction and Mining Equipment	Other Construction Equipment
2267003000	LPG	Industrial Equipment	All
2267003010	LPG	Industrial Equipment	Aerial Lifts
2267003020	LPG	Industrial Equipment	Forklifts
2267003030	LPG	Industrial Equipment	Sweepers/Scrubbers
2267003040	LPG	Industrial Equipment	Other General Industrial Equipment
2267003050	LPG	Industrial Equipment	Other Material Handling Equipment
2267003060	LPG	Industrial Equipment	AC\Refrigeration
2267003070	LPG	Industrial Equipment	Terminal Tractors
2267005000	LPG	Agricultural Equipment	All
2267005010	LPG	Agricultural Equipment	2-Wheel Tractors
2267005015	LPG	Agricultural Equipment	Agricultural Tractors
2267005020	LPG	Agricultural Equipment	Combines
2267005025	LPG	Agricultural Equipment	Balers
2267005030	LPG	Agricultural Equipment	Agricultural Mowers
2267005035	LPG	Agricultural Equipment	Sprayers
2267005040	LPG	Agricultural Equipment	Tillers >6 HP
2267005045	LPG	Agricultural Equipment	Swathers
2267005050	LPG	Agricultural Equipment	Hydro-power Units
2267005055	LPG	Agricultural Equipment	Other Agricultural Equipment

SCC	Description_2	Description_3	Description_4
2267005060	LPG	Agricultural Equipment	Irrigation Sets
2267007000	LPG	Logging Equipment	All
2267007005	LPG	Logging Equipment	Chain Saws > 6 HP
2267007010	LPG	Logging Equipment	Shredders > 6 HP
2267007015	LPG	Logging Equipment	Forest Eqp – Feller/Bunch/Skidder
2267009000	LPG	Underground Mining Equipment	All
2267009010	LPG	Underground Mining Equipment	Other Underground Mining Equipment
2267010000	LPG	Industrial Equipment	All
2267010010	LPG	Industrial Equipment	Other Oil Field Equipment
		Commercial Sector-Distillate	
2270004000	Off-highway Vehicle Diesel	Lawn and Garden Equipment	All
2270004011	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Lawn Mowers (Commercial)
2270004016	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Rotary Tillers < 6HP (Commercial)
2270004021	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Chain Saws < 6 HP (Commercial)
2270004026	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Trimmers/Edgers/Brush Cutters (Commercial)
2270004031	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Leafblowers/Vacuums (Commercial)
2270004036	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Snowblowers (Commercial)
2270004041	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Rear Engine Riding Mowers (Commercial)
2270004046	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Front Mowers (Commercial)
2270004051	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Shredders < 6 HP (Commercial)
2270004056	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Lawn and Garden Tractors (Commercial)
2270004061	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Wood Splitters (Commercial)
2270004066	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Chippers/Stump Grinders (Commercial)
2270004070	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Commercial Turf Equipment ** (use 22-70-004-71)
2270004071	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Turf Equipment (Commercial)
2270004076	Off-highway Vehicle Diesel	Lawn and Garden Equipment	Other Lawn and Garden Equipment (Commercial)
2270006000	Off-highway Vehicle Diesel	Commercial Equipment	Total
2270006005	Off-highway Vehicle Diesel	Commercial Equipment	Generator Sets
2270006010	Off-highway Vehicle Diesel	Commercial Equipment	Pumps

SCC	Description_2	Description_3	Description_4
2270006015	Off-highway Vehicle Diesel	Commercial Equipment	Air Compressors
2270006020	Off-highway Vehicle Diesel	Commercial Equipment	Gas Compressors
2270006025	Off-highway Vehicle Diesel	Commercial Equipment	Welders
2270006030	Off-highway Vehicle Diesel	Commercial Equipment	Pressure Washers
2270008000	Off-highway Vehicle Diesel	Airport Ground Support Equipment	Total
2270008005	Off-highway Vehicle Diesel	Airport Ground Support Equipment	Airport Ground Support Equipment
2270008010	Off-highway Vehicle Diesel	Airport Ground Support Equipment	Terminal Tractors
Commercial Sector-LPG			
22670004011	LPG	Lawn and Garden Equipment	Lawn Mowers (Commercial)
22670004016	LPG	Lawn and Garden Equipment	Rotary Tillers < 6 HP (Commercial)
22670004021	LPG	Lawn and Garden Equipment	Chain Saws < 6 HP (Commercial)
22670004026	LPG	Lawn and Garden Equipment	Trimmers/Edgers/Brush Cutters (Commercial)
22670004031	LPG	Lawn and Garden Equipment	Leafblowers/Vacuums (Commercial)
22670004036	LPG	Lawn and Garden Equipment	Snowblowers (Commercial)
22670004041	LPG	Lawn and Garden Equipment	Rear Engine Riding Mowers (Commercial)
22670004046	LPG	Lawn and Garden Equipment	Front Mowers (Commercial)
22670004051	LPG	Lawn and Garden Equipment	Shredders < 6 HP (Commercial)
22670004056	LPG	Lawn and Garden Equipment	Lawn and Garden Tractors (Commercial)
22670004061	LPG	Lawn and Garden Equipment	Wood Splitters (Commercial)
22670004066	LPG	Lawn and Garden Equipment	Chippers/Stump Grinders (Commercial)
22670004071	LPG	Lawn and Garden Equipment	Turf Equipment (Commercial)
22670004076	LPG	Lawn and Garden Equipment	Other Lawn and Garden Equipment (Commercial)
22670006000	LPG	Commercial Equipment	All
22670006005	LPG	Commercial Equipment	Generator Sets
22670006010	LPG	Commercial Equipment	Pumps
22670006015	LPG	Commercial Equipment	Air Compressors
22670006020	LPG	Commercial Equipment	Gas Compressors
22670006025	LPG	Commercial Equipment	Welders
22670006030	LPG	Commercial Equipment	Pressure Washers

4. Point Source Energy Consumption

To ensure that energy consumption is not double-counted in the point source inventory, it will also be necessary to subtract point source inventory fuel use from the fuel consumption estimates developed from the aforementioned data sources. To assist in the point source subtractions, Pechan has developed two crosswalks: one between each Industrial fuel combustion area SCC and associated point SCCs (Table 4), and an analogous crosswalk for Commercial/Institutional fuel combustion (Table 5). Pechan requests CENRAP comments on the point SCCs included in these crosswalks.

In addition, a summary analysis was performed on the throughput data reported in the 2002 point source inventory compiled for CENRAP (Pechan/CEP, 2005). The Attachment to this memorandum provides a summary of the 2002 annual point source throughput data associated with the ICI area source categories (reflecting use of the Table 4 and 5 crosswalks). As indicated by this summary, there appear to be numerous potential reporting errors in the CENRAP point source inventory throughput information. These errors include throughput reported using inappropriate units (e.g., reporting natural gas throughput in tons and distillate fuel throughput in million cubic feet), and throughput reported using an inappropriate material code (e.g., reporting a distillate fuel combustion category's throughput as water). There are also records with emissions that report throughput as zero and throughput data reported without any unit identifiers. Pechan requests guidance from CENRAP States as to revisions to the throughput information to ensure the validity of the data that are used in the point source subtractions. For States/source categories with suspect values for which revisions are not available, Pechan will estimate throughput by dividing point source emissions by the carbon monoxide (CO) emission factors listed in the next section. The CO-based approach will also be used for all States that do not report any throughput data for ICI point source fuel combustion categories (i.e., Louisiana and Texas).

To ensure that the methodology results in accurate estimates of point source throughput, Pechan will supply States with the SEDS energy consumption estimates by fuel type and the point source energy consumption by fuel type computed using the throughput or CO emissions-based approach. Pechan will wait for State approval of these estimates before final use in the point source subtraction procedure.

Table 4. Industrial Fuel Combustion Crosswalk for Point Source Subtractions

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
2102001000 & 2102002000 – Industrial; Anthracite Coal; Total: All Boiler Types and Bituminous/Subbituminous Coal; Total: All Boiler Types				
10200101	External Combustion Boilers	Industrial	Anthracite Coal	Pulverized Coal
10200104	External Combustion Boilers	Industrial	Anthracite Coal	Traveling Grate (Overfeed) Stoker
10200107	External Combustion Boilers	Industrial	Anthracite Coal	Hand-fired
10200117	External Combustion Boilers	Industrial	Anthracite Coal	Fluidized Bed Boiler Burning Anthracite-Culm Fuel
39000189	Industrial Processes	In-process Fuel Use	Anthracite Coal	General
39000199	Industrial Processes	In-process Fuel Use	Anthracite Coal	General
10200201	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom
10200202	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom
10200203	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Cyclone Furnace
10200204	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Spreader Stoker
10200205	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Overfeed Stoker
10200206	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Underfeed Stoker
10200210	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Overfeed Stoker **
10200212	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential)
10200213	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Wet Slurry
10200217	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bituminous Coal)
10200218	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Atmospheric Fluidized Bed Combustion: Circulating Bed (Bitum. Coal)
10200219	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Cogeneration (Bituminous Coal)
10200221	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom (Subbituminous Coal)
10200222	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Subbituminous Coal)
10200223	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Cyclone Furnace (Subbituminous Coal)
10200224	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Spreader Stoker (Subbituminous Coal)
10200225	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Traveling Grate (Overfeed) Stoker (Subbituminous Coal)
10200226	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)
10200229	External Combustion Boilers	Industrial	Bituminous/Subbituminous Coal	Cogeneration (Subbituminous Coal)
10500102	External Combustion Boilers	Space Heaters	Industrial	Coal **
39000201	Industrial Processes	In-process Fuel Use	Bituminous Coal	Cement Kiln/Dryer (Bituminous Coal)
39000203	Industrial Processes	In-process Fuel Use	Bituminous Coal	Lime Kiln (Bituminous)
39000288	Industrial Processes	In-process Fuel Use	Bituminous Coal	General (Subbituminous)
39000289	Industrial Processes	In-process Fuel Use	Bituminous Coal	General (Bituminous)
39000299	Industrial Processes	In-process Fuel Use	Bituminous Coal	General (Bituminous)
50390002	Waste Disposal	Solid Waste Disposal - Industrial	Auxiliary Fuel/No Emissions	Coal

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
2102004000 – Industrial; Distillate Oil; Total: Boilers and IC Engines				
10200501	External Combustion Boilers	Industrial	Distillate Oil	Grades 1 and 2 Oil
10200502	External Combustion Boilers	Industrial	Distillate Oil	10-100 Million Btu/hr **
10200503	External Combustion Boilers	Industrial	Distillate Oil	< 10 Million Btu/hr **
10200504	External Combustion Boilers	Industrial	Distillate Oil	Grade 4 Oil
10200505	External Combustion Boilers	Industrial	Distillate Oil	Cogeneration
10201403	External Combustion Boilers	Industrial	CO Boiler	Distillate Oil
10500105	External Combustion Boilers	Space Heaters	Industrial	Distillate Oil
20200101	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Turbine
20200102	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Reciprocating
20200103	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Turbine: Cogeneration
20200104	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Reciprocating: Cogeneration
20200105	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Reciprocating: Crankcase Blowby
20200106	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)
20200107	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Reciprocating: Exhaust
20200108	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Turbine: Evaporative Losses (Fuel Storage and Delivery System)
20200109	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Turbine: Exhaust
20200401	Internal Combustion Engines	Industrial	Large Bore Engine	Diesel
20200405	Internal Combustion Engines	Industrial	Large Bore Engine	Crankcase Blowby
20200406	Internal Combustion Engines	Industrial	Large Bore Engine	Evaporative Losses (Fuel Storage and Delivery System)
20200407	Internal Combustion Engines	Industrial	Large Bore Engine	Exhaust
27000320	Internal Combustion Engines	Off-highway Diesel Engines	Industrial Equipment	Industrial Fork Lift: Diesel
30190001	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	Distillate Oil (No. 2): Process Heaters
30190011	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	Distillate Oil (No. 2): Incinerators
30190021	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	Distillate Oil (No. 2): Flares
30290001	Industrial Processes	Food and Agriculture	Fuel Fired Equipment	Distillate Oil (No. 2): Process Heaters
30390001	Industrial Processes	Primary Metal Production	Fuel Fired Equipment	Distillate Oil (No. 2): Process Heaters
30390011	Industrial Processes	Primary Metal Production	Fuel Fired Equipment	Distillate Oil (No. 2): Incinerators
30390021	Industrial Processes	Primary Metal Production	Fuel Fired Equipment	Distillate Oil (No. 2): Flares
30400406	Industrial Processes	Secondary Metal Production	Lead	Pot Furnace Heater: Distillate Oil
30490001	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Distillate Oil (No. 2): Process Heaters
30490011	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Distillate Oil (No. 2): Incinerators
30490021	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Distillate Oil (No. 2): Flares
30490031	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Distillate Oil (No. 2): Furnaces
30500208	Industrial Processes	Mineral Products	Asphalt Concrete	Asphalt Heater: Distillate Oil
30505022	Industrial Processes	Mineral Products	Asphalt Processing (Blowing)	Asphalt Heater: Distillate Oil
30590001	Industrial Processes	Mineral Products	Fuel Fired Equipment	Distillate Oil (No. 2): Process Heaters
30590011	Industrial Processes	Mineral Products	Fuel Fired Equipment	Distillate Oil (No. 2): Incinerators
30590021	Industrial Processes	Mineral Products	Fuel Fired Equipment	Distillate Oil (No. 2): Flares

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
30600901	Industrial Processes	Petroleum Industry	Flares	Distillate Oil
30609901	Industrial Processes	Petroleum Industry	Incinerators	Distillate Oil (No. 2)
30790001	Industrial Processes	Pulp and Paper and Wood Products	Fuel Fired Equipment	Distillate Oil (No. 2): Process Heaters
30790011	Industrial Processes	Pulp and Paper and Wood Products	Fuel Fired Equipment	Distillate Oil (No. 2): Incinerators
30790021	Industrial Processes	Pulp and Paper and Wood Products	Fuel Fired Equipment	Distillate Oil (No. 2): Flares
30890001	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Distillate Oil (No. 2): Process Heaters
30890011	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Distillate Oil (No. 2): Incinerators
30890021	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Distillate Oil (No. 2): Flares
30990001	Industrial Processes	Fabricated Metal Products	Fuel Fired Equipment	Distillate Oil (No. 2): Process Heaters
30990011	Industrial Processes	Fabricated Metal Products	Fuel Fired Equipment	Distillate Oil (No. 2): Incinerators
31000401	Industrial Processes	Oil and Gas Production	Process Heaters	Distillate Oil (No. 2)
31000411	Industrial Processes	Oil and Gas Production	Process Heaters	Distillate Oil (No. 2): Steam Generators
31390001	Industrial Processes	Electrical Equipment	Process Heaters	Distillate Oil (No. 2)
39000501	Industrial Processes	In-process Fuel Use	Distillate Oil	Asphalt Dryer **
39000502	Industrial Processes	In-process Fuel Use	Distillate Oil	Cement Kiln/Dryer
39000503	Industrial Processes	In-process Fuel Use	Distillate Oil	Lime Kiln
39000589	Industrial Processes	In-process Fuel Use	Distillate Oil	General
39000598	Industrial Processes	In-process Fuel Use	Distillate Oil	Grade 4 Oil: General
39000599	Industrial Processes	In-process Fuel Use	Distillate Oil	General
39900501	Industrial Processes	Miscellaneous Manufacturing Industries	Process Heater/Furnace	Distillate Oil
39990001	Industrial Processes	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industries	Distillate Oil (No. 2): Process Heaters
39990011	Industrial Processes	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industries	Distillate Oil (No. 2): Incinerators
39990021	Industrial Processes	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industries	Distillate Oil (No. 2 Oil): Flares
40201002	Petroleum and Solvent Evaporation	Surface Coating Operations	Coating Oven Heater	Distillate Oil
40290011	Petroleum and Solvent Evaporation	Surface Coating Operations	Fuel Fired Equipment	Distillate Oil: Incinerator/Afterburner
49090011	Petroleum and Solvent Evaporation	Organic Solvent Evaporation	Fuel Fired Equipment	Distillate Oil (No. 2): Incinerators
49090021	Petroleum and Solvent Evaporation	Organic Solvent Evaporation	Fuel Fired Equipment	Distillate Oil (No. 2): Flares
50390005	Waste Disposal	Solid Waste Disposal - Industrial	Auxiliary Fuel/No Emissions	Distillate Oil
2102005000 – Industrial; Residual Oil; Total: All Boiler Types				
10200401	External Combustion Boilers	Industrial	Residual Oil	Grade 6 Oil

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
10200402	External Combustion Boilers	Industrial	Residual Oil	10-100 Million Btu/hr **
10200403	External Combustion Boilers	Industrial	Residual Oil	< 10 Million Btu/hr **
10200404	External Combustion Boilers	Industrial	Residual Oil	Grade 5 Oil
10200405	External Combustion Boilers	Industrial	Residual Oil	Cogeneration
10201404	External Combustion Boilers	Industrial	CO Boiler	Residual Oil
20200501	Internal Combustion Engines	Industrial	Residual/Crude Oil	Reciprocating
20200505	Internal Combustion Engines	Industrial	Residual/Crude Oil	Reciprocating: Crankcase Blowby
20200506	Internal Combustion Engines	Industrial	Residual/Crude Oil	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)
20200507	Internal Combustion Engines	Industrial	Residual/Crude Oil	Reciprocating: Exhaust
30190002	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	Residual Oil: Process Heaters
30190012	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	Residual Oil: Incinerators
30190022	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	Residual Oil: Flares
30290002	Industrial Processes	Food and Agriculture	Fuel Fired Equipment	Residual Oil: Process Heaters
30390002	Industrial Processes	Primary Metal Production	Fuel Fired Equipment	Residual Oil: Process Heaters
30390012	Industrial Processes	Primary Metal Production	Fuel Fired Equipment	Residual Oil: Incinerators
30390022	Industrial Processes	Primary Metal Production	Fuel Fired Equipment	Residual Oil: Flares
30490002	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Residual Oil: Process Heaters
30490012	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Residual Oil: Incinerators
30490022	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Residual Oil: Flares
30490032	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Residual Oil: Furnaces
30500207	Industrial Processes	Mineral Products	Asphalt Concrete	Asphalt Heater: Residual Oil
30505021	Industrial Processes	Mineral Products	Asphalt Processing (Blowing)	Asphalt Heater: Residual Oil
30590002	Industrial Processes	Mineral Products	Fuel Fired Equipment	Residual Oil: Process Heaters
30590012	Industrial Processes	Mineral Products	Fuel Fired Equipment	Residual Oil: Incinerators
30600111	Industrial Processes	Petroleum Industry	Process Heaters	Oil-fired (No. 6 Oil) > 100 Million Btu Capacity
30600902	Industrial Processes	Petroleum Industry	Flares	Residual Oil
30609902	Industrial Processes	Petroleum Industry	Incinerators	Residual Oil
30790002	Industrial Processes	Pulp and Paper and Wood Products	Fuel Fired Equipment	Residual Oil: Process Heaters
30790012	Industrial Processes	Pulp and Paper and Wood Products	Fuel Fired Equipment	Residual Oil: Incinerators
30790022	Industrial Processes	Pulp and Paper and Wood Products	Fuel Fired Equipment	Residual Oil: Flares
30890002	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Residual Oil: Process Heaters
30890012	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Residual Oil: Incinerators
30890022	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Residual Oil: Flares
30990002	Industrial Processes	Fabricated Metal Products	Fuel Fired Equipment	Residual Oil: Process Heaters
30990012	Industrial Processes	Fabricated Metal Products	Fuel Fired Equipment	Residual Oil: Incinerators
31000402	Industrial Processes	Oil and Gas Production	Process Heaters	Residual Oil

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
31000412	Industrial Processes	Oil and Gas Production	Process Heaters	Residual Oil: Steam Generators
31390002	Industrial Processes	Electrical Equipment	Process Heaters	Residual Oil
39000402	Industrial Processes	In-process Fuel Use	Residual Oil	Cement Kiln/Dryer
39000403	Industrial Processes	In-process Fuel Use	Residual Oil	Lime Kiln
39000489	Industrial Processes	In-process Fuel Use	Residual Oil	General
39000499	Industrial Processes	In-process Fuel Use	Residual Oil	General
39990002	Industrial Processes	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industries	Residual Oil: Process Heaters
39990012	Industrial Processes	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industries	Residual Oil: Incinerators
39990022	Industrial Processes	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industries	Residual Oil: Flares
40201003	Petroleum and Solvent Evaporation	Surface Coating Operations	Coating Oven Heater	Residual Oil
40290012	Petroleum and Solvent Evaporation	Surface Coating Operations	Fuel Fired Equipment	Residual Oil: Incinerator/Afterburner
49090012	Petroleum and Solvent Evaporation	Organic Solvent Evaporation	Fuel Fired Equipment	Residual Oil: Incinerators
49090022	Petroleum and Solvent Evaporation	Organic Solvent Evaporation	Fuel Fired Equipment	Residual Oil: Flares
2102006000 – Industrial; Natural Gas; Total: Boilers and IC Engines				
10200601	External Combustion Boilers	Industrial	Natural Gas	> 100 Million Btu/hr
10200602	External Combustion Boilers	Industrial	Natural Gas	10-100 Million Btu/hr
10200603	External Combustion Boilers	Industrial	Natural Gas	< 10 Million Btu/hr
10200604	External Combustion Boilers	Industrial	Natural Gas	Cogeneration
10201401	External Combustion Boilers	Industrial	CO Boiler	Natural Gas
10500106	External Combustion Boilers	Space Heaters	Industrial	Natural Gas
20200201	Internal Combustion Engines	Industrial	Natural Gas	Turbine
20200202	Internal Combustion Engines	Industrial	Natural Gas	Reciprocating
20200203	Internal Combustion Engines	Industrial	Natural Gas	Turbine: Cogeneration
20200204	Internal Combustion Engines	Industrial	Natural Gas	Reciprocating: Cogeneration
20200205	Internal Combustion Engines	Industrial	Natural Gas	Reciprocating: Crankcase Blowby
20200206	Internal Combustion Engines	Industrial	Natural Gas	Reciprocating: Evaporative Losses (Fuel Delivery System)
20200207	Internal Combustion Engines	Industrial	Natural Gas	Reciprocating: Exhaust
20200208	Internal Combustion Engines	Industrial	Natural Gas	Turbine: Evaporative Losses (Fuel Delivery System)
20200209	Internal Combustion Engines	Industrial	Natural Gas	Turbine: Exhaust
20200252	Internal Combustion Engines	Industrial	Natural Gas	2-cycle Lean Burn
20200253	Internal Combustion Engines	Industrial	Natural Gas	4-cycle Rich Burn
20200254	Internal Combustion Engines	Industrial	Natural Gas	4-cycle Lean Burn
20200255	Internal Combustion Engines	Industrial	Natural Gas	2-cycle Clean Burn
20200256	Internal Combustion Engines	Industrial	Natural Gas	4-cycle Clean Burn
30190003	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	Natural Gas: Process Heaters

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
30190013	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	Natural Gas: Incinerators
30190023	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	Natural Gas: Flares
30290003	Industrial Processes	Food and Agriculture	Fuel Fired Equipment	Natural Gas: Process Heaters
30291001	Industrial Processes	Food and Agriculture	Fuel Fired Equipment	Broiling Food: Natural Gas
30390003	Industrial Processes	Primary Metal Production	Fuel Fired Equipment	Natural Gas: Process Heaters
30390013	Industrial Processes	Primary Metal Production	Fuel Fired Equipment	Natural Gas: Incinerators
30390023	Industrial Processes	Primary Metal Production	Fuel Fired Equipment	Natural Gas: Flares
30400407	Industrial Processes	Secondary Metal Production	Lead	Pot Furnace Heater: Natural Gas
30490003	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Natural Gas: Process Heaters
30490013	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Natural Gas: Incinerators
30490023	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Natural Gas: Flares
30490033	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Natural Gas: Furnaces
30500206	Industrial Processes	Mineral Products	Asphalt Concrete	Asphalt Heater: Natural Gas
30505020	Industrial Processes	Mineral Products	Asphalt Processing (Blowing)	Asphalt Heater: Natural Gas
30590003	Industrial Processes	Mineral Products	Fuel Fired Equipment	Natural Gas: Process Heaters
30590013	Industrial Processes	Mineral Products	Fuel Fired Equipment	Natural Gas: Incinerators
30590023	Industrial Processes	Mineral Products	Fuel Fired Equipment	Natural Gas: Flares
30790003	Industrial Processes	Pulp and Paper and Wood Products	Fuel Fired Equipment	Natural Gas: Process Heaters
30790013	Industrial Processes	Pulp and Paper and Wood Products	Fuel Fired Equipment	Natural Gas: Incinerators
30790023	Industrial Processes	Pulp and Paper and Wood Products	Fuel Fired Equipment	Natural Gas: Flares
30890003	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Natural Gas: Process Heaters
30890013	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Natural Gas: Incinerators
30890023	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Natural Gas: Flares
30990003	Industrial Processes	Fabricated Metal Products	Fuel Fired Equipment	Natural Gas: Process Heaters
30990013	Industrial Processes	Fabricated Metal Products	Fuel Fired Equipment	Natural Gas: Incinerators
30990023	Industrial Processes	Fabricated Metal Products	Fuel Fired Equipment	Natural Gas: Flares
31000404	Industrial Processes	Oil and Gas Production	Process Heaters	Natural Gas
31000414	Industrial Processes	Oil and Gas Production	Process Heaters	Natural Gas: Steam Generators
31390003	Industrial Processes	Electrical Equipment	Process Heaters	Natural Gas
39000602	Industrial Processes	In-process Fuel Use	Natural Gas	Cement Kiln/Dryer
39000603	Industrial Processes	In-process Fuel Use	Natural Gas	Lime Kiln
39000605	Industrial Processes	In-process Fuel Use	Natural Gas	Metal Melting **
39000689	Industrial Processes	In-process Fuel Use	Natural Gas	General
39000699	Industrial Processes	In-process Fuel Use	Natural Gas	General
39900601	Industrial Processes	Miscellaneous Manufacturing Industries	Process Heater/Furnace	Natural Gas
39990003	Industrial Processes	Miscellaneous Manufacturing	Miscellaneous Manufacturing	Natural Gas: Process Heaters

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
		Industries	Industries	
39990013	Industrial Processes	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industries	Natural Gas: Incinerators
39990023	Industrial Processes	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industries	Natural Gas: Flares
40201001	Petroleum and Solvent Evaporation	Surface Coating Operations	Coating Oven Heater	Natural Gas
40290013	Petroleum and Solvent Evaporation	Surface Coating Operations	Fuel Fired Equipment	Natural Gas: Incinerator/Afterburner
40290023	Petroleum and Solvent Evaporation	Surface Coating Operations	Fuel Fired Equipment	Natural Gas: Flares
49090013	Petroleum and Solvent Evaporation	Organic Solvent Evaporation	Fuel Fired Equipment	Natural Gas: Incinerators
49090023	Petroleum and Solvent Evaporation	Organic Solvent Evaporation	Fuel Fired Equipment	Natural Gas: Flares
50390006	Waste Disposal	Solid Waste Disposal - Industrial	Auxiliary Fuel/No Emissions	Natural Gas
2102007000 – Industrial; Liquified Petroleum Gas (LPG); Total: All Boiler Types				
10201001	External Combustion Boilers	Industrial	Liquified Petroleum Gas (LPG)	Butane
10201002	External Combustion Boilers	Industrial	Liquified Petroleum Gas (LPG)	Propane
10201003	External Combustion Boilers	Industrial	Liquified Petroleum Gas (LPG)	Butane/Propane Mixture: Specify Percent Butane in Comments
10500110	External Combustion Boilers	Space Heaters	Industrial	Liquified Petroleum Gas (LPG)
20201001	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Propane: Reciprocating
20201002	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Butane: Reciprocating
20201005	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Reciprocating: Crankcase Blowby
20201006	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)
20201007	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Reciprocating: Exhaust
20201008	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Turbine: Evaporative Losses (Fuel Storage and Delivery System)
20201009	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Turbine: Exhaust
20201011	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Turbine
20201012	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Reciprocating Engine
20201013	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Turbine: Cogeneration
20201014	Internal Combustion Engines	Industrial	Liquified Petroleum Gas (LPG)	Reciprocating Engine: Cogeneration
27300320	Internal Combustion Engines	Off-highway LPG-fueled Engines	Industrial Equipment	Industrial Fork Lift: Liquified Petroleum Gas (LPG)
30290005	Industrial Processes	Food and Agriculture	Fuel Fired Equipment	Liquified Petroleum Gas (LPG): Process Heaters
30490035	Industrial Processes	Secondary Metal Production	Fuel Fired Equipment	Propane: Furnaces
30500209	Industrial Processes	Mineral Products	Asphalt Concrete	Asphalt Heater: LPG
30505023	Industrial Processes	Mineral Products	Asphalt Processing (Blowing)	Asphalt Heater: LP Gas
30590005	Industrial Processes	Mineral Products	Fuel Fired Equipment	Liquified Petroleum Gas (LPG): Process Heaters
30600107	Industrial Processes	Petroleum Industry	Process Heaters	LPG-fired
30600905	Industrial Processes	Petroleum Industry	Flares	Liquified Petroleum Gas

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
30609905	Industrial Processes	Petroleum Industry	Incinerators	Liquified Petroleum Gas
30890004	Industrial Processes	Rubber and Miscellaneous Plastics Products	Fuel Fired Equipment	Liquified Petroleum Gas (LPG): Process Heaters
31000406	Industrial Processes	Oil and Gas Production	Process Heaters	Propane/Butane
39001089	Industrial Processes	In-process Fuel Use	Liquified Petroleum Gas	General
39001099	Industrial Processes	In-process Fuel Use	Liquified Petroleum Gas	General
39901001	Industrial Processes	Miscellaneous Manufacturing Industries	Process Heater/Furnace	LPG
40201004	Petroleum and Solvent Evaporation	Surface Coating Operations	Coating Oven Heater	Liquified Petroleum Gas (LPG)
50390010	Waste Disposal	Solid Waste Disposal - Industrial	Auxiliary Fuel/No Emissions	Liquified Petroleum Gas (LPG)
2102008000 – Industrial; Wood; Total: All Boiler Types				
10200902	External Combustion Boilers	Industrial	Wood/Bark Waste	Wood/Bark-fired Boiler
10200903	External Combustion Boilers	Industrial	Wood/Bark Waste	Wood-fired Boiler - Wet Wood (>=20% moisture)
10200905	External Combustion Boilers	Industrial	Wood/Bark Waste	Wood/Bark-fired Boiler (< 50,000 Lb Steam) **
10200906	External Combustion Boilers	Industrial	Wood/Bark Waste	Wood-fired Boiler (< 50,000 Lb Steam) **
10200907	External Combustion Boilers	Industrial	Wood/Bark Waste	Wood Cogeneration
10200908	External Combustion Boilers	Industrial	Wood/Bark Waste	Wood-fired Boiler - Dry Wood (<20% moisture)
10200910	External Combustion Boilers	Industrial	Wood/Bark Waste	Fuel cell/Dutch oven boilers **
10200911	External Combustion Boilers	Industrial	Wood/Bark Waste	Stoker boilers **
10200912	External Combustion Boilers	Industrial	Wood/Bark Waste	Fluidized bed combustion boiler
39000989	Industrial Processes	In-process Fuel Use	Wood	General
39000999	Industrial Processes	In-process Fuel Use	Wood	General: Wood
2102011000 – Industrial; Kerosene; Total: All Boiler Types				
20200901	Internal Combustion Engines	Industrial	Kerosene/Naphtha (Jet Fuel)	Turbine
20200902	Internal Combustion Engines	Industrial	Kerosene/Naphtha (Jet Fuel)	Reciprocating
20200905	Internal Combustion Engines	Industrial	Kerosene/Naphtha (Jet Fuel)	Reciprocating: Crankcase Blowby
20200906	Internal Combustion Engines	Industrial	Kerosene/Naphtha (Jet Fuel)	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)
20200907	Internal Combustion Engines	Industrial	Kerosene/Naphtha (Jet Fuel)	Reciprocating: Exhaust
20200908	Internal Combustion Engines	Industrial	Kerosene/Naphtha (Jet Fuel)	Turbine: Evaporative Losses (Fuel Storage and Delivery System)
20200909	Internal Combustion Engines	Industrial	Kerosene/Naphtha (Jet Fuel)	Turbine: Exhaust

Table 5. Commercial/Institutional Fuel Combustion Crosswalk for Point Source Subtractions

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
2103001000 & 2103002000 -- Commercial/Institutional; Anthracite Coal; Total: All Boiler Types and Bituminous/Subbituminous Coal; Total: All Boiler Types				
10300101	External Combustion Boilers	Commercial/Institutional	Anthracite Coal	Pulverized Coal
10300102	External Combustion Boilers	Commercial/Institutional	Anthracite Coal	Traveling Grate (Overfeed) Stoker
10300103	External Combustion Boilers	Commercial/Institutional	Anthracite Coal	Hand-fired
10300203	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Cyclone Furnace (Bituminous Coal)
10300205	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom (Bituminous Coal)
10300206	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Bituminous Coal)
10300207	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Overfeed Stoker (Bituminous Coal)
10300208	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Underfeed Stoker (Bituminous Coal)
10300209	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Spreader Stoker (Bituminous Coal)
10300211	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Overfeed Stoker **
10300214	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Hand-fired (Bituminous Coal)
10300216	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)
10300217	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bituminous Coal)
10300218	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Atmospheric Fluidized Bed Combustion: Circulating Bed (Bitum. Coal)
10300221	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Pulverized Coal: Wet Bottom (Subbituminous Coal)
10300222	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom (Subbituminous Coal)
10300223	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Cyclone Furnace (Subbituminous Coal)
10300224	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Spreader Stoker (Subbituminous Coal)
10300225	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Traveling Grate (Overfeed) Stoker (Subbituminous Coal)
10300226	External Combustion Boilers	Commercial/Institutional	Bituminous/Subbituminous Coal	Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)
10500202	External Combustion Boilers	Space Heaters	Commercial/Institutional	Coal **
50190002	Waste Disposal	Solid Waste Disposal - Government	Auxiliary Fuel/No Emissions	Coal
50290002	Waste Disposal	Solid Waste Disposal - Commercial/Institutional	Auxiliary Fuel/No Emissions	Coal
2103004000 -- Commercial/Institutional; Distillate Oil; Total: Boilers and IC Engines				
10300501	External Combustion Boilers	Commercial/Institutional	Distillate Oil	Grades 1 and 2 Oil
10300502	External Combustion Boilers	Commercial/Institutional	Distillate Oil	10-100 Million Btu/hr **
10300503	External Combustion Boilers	Commercial/Institutional	Distillate Oil	< 10 Million Btu/hr **
10300504	External Combustion Boilers	Commercial/Institutional	Distillate Oil	Grade 4 Oil
10500205	External Combustion Boilers	Space Heaters	Commercial/Institutional	Distillate Oil
20300101	Internal Combustion Engines	Commercial/Institutional	Distillate Oil (Diesel)	Reciprocating
20300102	Internal Combustion Engines	Commercial/Institutional	Distillate Oil (Diesel)	Turbine

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
20300105	Internal Combustion Engines	Commercial/Institutional	Distillate Oil (Diesel)	Reciprocating: Crankcase Blowby
20300106	Internal Combustion Engines	Commercial/Institutional	Distillate Oil (Diesel)	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)
20300107	Internal Combustion Engines	Commercial/Institutional	Distillate Oil (Diesel)	Reciprocating: Exhaust
20300108	Internal Combustion Engines	Commercial/Institutional	Distillate Oil (Diesel)	Turbine: Evaporative Losses (Fuel Storage and Delivery System)
20300109	Internal Combustion Engines	Commercial/Institutional	Distillate Oil (Diesel)	Turbine: Exhaust
50190005	Waste Disposal	Solid Waste Disposal - Government	Auxiliary Fuel/No Emissions	Distillate Oil
50290005	Waste Disposal	Solid Waste Disposal - Commercial/Institutional	Auxiliary Fuel/No Emissions	Distillate Oil
2103005000 -- Commercial/Institutional; Residual Oil; Total: All Boiler Types				
10300401	External Combustion Boilers	Commercial/Institutional	Residual Oil	Grade 6 Oil
10300402	External Combustion Boilers	Commercial/Institutional	Residual Oil	10-100 Million Btu/hr **
10300403	External Combustion Boilers	Commercial/Institutional	Residual Oil	< 10 Million Btu/hr **
10300404	External Combustion Boilers	Commercial/Institutional	Residual Oil	Grade 5 Oil
2103006000 -- Commercial/Institutional; Natural Gas; Total: Boilers and IC Engines				
10300601	External Combustion Boilers	Commercial/Institutional	Natural Gas	> 100 Million Btu/hr
10300602	External Combustion Boilers	Commercial/Institutional	Natural Gas	10-100 Million Btu/hr
10300603	External Combustion Boilers	Commercial/Institutional	Natural Gas	< 10 Million Btu/hr
10500206	External Combustion Boilers	Space Heaters	Commercial/Institutional	Natural Gas
20300201	Internal Combustion Engines	Commercial/Institutional	Natural Gas	Reciprocating
20300202	Internal Combustion Engines	Commercial/Institutional	Natural Gas	Turbine
20300203	Internal Combustion Engines	Commercial/Institutional	Natural Gas	Turbine: Cogeneration
20300204	Internal Combustion Engines	Commercial/Institutional	Natural Gas	Cogeneration
20300205	Internal Combustion Engines	Commercial/Institutional	Natural Gas	Reciprocating: Crankcase Blowby
20300206	Internal Combustion Engines	Commercial/Institutional	Natural Gas	Reciprocating: Evaporative Losses (Fuel Delivery System)
20300207	Internal Combustion Engines	Commercial/Institutional	Natural Gas	Reciprocating: Exhaust
20300208	Internal Combustion Engines	Commercial/Institutional	Natural Gas	Turbine: Evaporative Losses (Fuel Delivery System)
20300209	Internal Combustion Engines	Commercial/Institutional	Natural Gas	Turbine: Exhaust
50190006	Waste Disposal	Solid Waste Disposal - Government	Auxiliary Fuel/No Emissions	Natural Gas
50290006	Waste Disposal	Solid Waste Disposal - Commercial/Institutional	Auxiliary Fuel/No Emissions	Natural Gas
2103007000 -- Commercial/Institutional; Liquid Petroleum Gas; Total: All Combustor Types				
10301001	External Combustion Boilers	Commercial/Institutional	Liquified Petroleum Gas (LPG)	Butane
10301002	External Combustion Boilers	Commercial/Institutional	Liquified Petroleum Gas (LPG)	Propane
10301003	External Combustion Boilers	Commercial/Institutional	Liquified Petroleum Gas (LPG)	Butane/Propane Mixture: Specify Percent Butane in Comments
10500210	External Combustion Boilers	Space Heaters	Commercial/Institutional	Liquified Petroleum Gas (LPG)
20301001	Internal Combustion Engines	Commercial/Institutional	Liquified Petroleum Gas (LPG)	Propane: Reciprocating
20301002	Internal Combustion Engines	Commercial/Institutional	Liquified Petroleum Gas (LPG)	Butane: Reciprocating

Point SCC	SCC1 DESC	SCC3 DESC	SCC6 DESC	SCC8 DESC
20301005	Internal Combustion Engines	Commercial/Institutional	Liquified Petroleum Gas (LPG)	Reciprocating: Crankcase Blowby
20301006	Internal Combustion Engines	Commercial/Institutional	Liquified Petroleum Gas (LPG)	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)
20301007	Internal Combustion Engines	Commercial/Institutional	Liquified Petroleum Gas (LPG)	Reciprocating: Exhaust
50190010	Waste Disposal	Solid Waste Disposal - Government	Auxiliary Fuel/No Emissions	Liquified Petroleum Gas (LPG)
50290010	Waste Disposal	Solid Waste Disposal - Commercial/Institutional	Auxiliary Fuel/No Emissions	Liquified Petroleum Gas (LPG)
2103008000 -- Commercial/Institutional; Wood; Total: All Boiler Types				
10300902	External Combustion Boilers	Commercial/Institutional	Wood/Bark Waste	Wood/Bark-fired Boiler
10300903	External Combustion Boilers	Commercial/Institutional	Wood/Bark Waste	Wood-fired Boiler - Wet Wood (>=20% moisture)
10300908	External Combustion Boilers	Commercial/Institutional	Wood/Bark Waste	Wood-fired Boiler - Dry Wood (<20% moisture)
10300910	External Combustion Boilers	Commercial/Institutional	Wood/Bark Waste	Fuel cell/Dutch oven boilers **
10300911	External Combustion Boilers	Commercial/Institutional	Wood/Bark Waste	Stoker boilers **
10300912	External Combustion Boilers	Commercial/Institutional	Wood/Bark Waste	Fluidized bed combustion boilers
10500209	External Combustion Boilers	Space Heaters	Commercial/Institutional	Wood
2103011000 -- Commercial/Institutional; Kerosene; Total: All Combustor Types				
20300901	Internal Combustion Engines	Commercial/Institutional	Kerosene/Naphtha (Jet Fuel)	Turbine: JP-4
20300908	Internal Combustion Engines	Commercial/Institutional	Kerosene/Naphtha (Jet Fuel)	Turbine: Evaporative Losses (Fuel Storage and Delivery System)
20300909	Internal Combustion Engines	Commercial/Institutional	Kerosene/Naphtha (Jet Fuel)	Turbine: Exhaust
50100603	Waste Disposal	Solid Waste Disposal - Government	Fire Fighting	Structure: Kerosene

5. Emission Factors

Table 6 presents the criteria pollutant emission factors that will be applied to fuel consumption estimates to calculate ICI combustion area source emissions. Except as noted below, all criteria air pollutant emission factors were from an EPA database of emission factors that will be used in preparing the 2008 nonpoint source NEI (Huntley, 2009).[2] Wood combustion emission factors were compiled from *AP-42* (EPA, 2003). Because there are no NH_3 emission factors for ICI fuel combustion available in the 2008 NEI emission factor database, *AP-42*, or EPA's WebFIRE, Pechan will use emission factors reported in an NH_3 emissions Emission Inventory Improvement Program (EIIP) guidance document (Pechan, 2004). Pechan compared the 2008 NEI emission factors with those used to develop the last area source NEI (2002), as well as those listed by the Eastern Regional Technical Advisory Committee (ERTAC) for potential use by States in developing their area source inventories (ERTAC, 2009). With a few notable exceptions, the 2008 NEI emission factors are the same as those used for the 2002 NEI.[3] The PM emission factors for natural gas and LPG combustion are the major exceptions. Because the 2002 emission factors were deemed too high because of artifact formation in the test method (method 202) during stack testing, EPA developed a set of SCC-specific adjustment factors to apply to the 2002 NEI to better reflect PM emissions from these fuels.[4] In preparation for the 2008 NEI, EPA developed revised natural gas and LPG PM emission factors by applying these adjustment factors to the 2002 NEI emission factors.

Pechan does not plan to use the ERTAC emission factors that differ from the 2008 NEI factors because of the lack of documentation as to the source of the ERTAC factors. For PM emissions from ICI bituminous coal combustion, ERTAC specifically notes that their proposed emission factors reflect combustion in an uncontrolled overfeed stoker. The EPA PM emission factors for these categories, which were obtained from *AP-42*, reflect coal-fired boilers with controls (specifically, multiple cyclones with or without fly ash reinjection). Because an analysis of an EPA boiler database indicates that most small coal-fired boilers have PM controls (with cyclones as the most common type of control), EPA's PM emission factors will be used in preparing the CENRAP emission inventory (ERG, 2002).

For greenhouse gases (GHGs), Pechan will use the emission factors from EPA's State Greenhouse Gas Inventory Tool, which incorporates the EIIP's GHG emissions inventory guidelines for States (EPA, 2009). Table 7 displays the State-specific CO_2 emission factors for each ICI combustion area source category, and Table 8 presents the N_2O and CH_4 emission factors by source category. Because SIT assumes that CO_2 emissions from U.S. biomass combustion need not be inventoried, the SIT does not provide CO_2 emission factors for ICI wood combustion.[5] Therefore, Pechan will use the wood combustion CO_2 emission factors reported in *AP-42* (EPA, 2003).

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[2] All criteria pollutant emission factors were rounded to two decimal places.

[3] The 2002 NEI documentation provides citations to the *AP-42* source for each emission factor (Pechan, 2006).

[4] These factors reduce PM emissions by more than 90 percent.

[5] As stated in the EIIP fossil fuel combustion CO_2 emissions guidance: "…biomass fuels are generally grown on a sustainable basis. … In cases where biomass fuels are not grown sustainably, GHG emissions are captured as a land use change."

Table 6. Criteria Pollutant Emission Factors for ICI Combustion Area Source Categories

SCC	Description	Emission Factor Units	VOC	NO_x	CO	SO_2	PM2.5-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	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	0.13	0.32	3.2
2102007000	Industrial LPG [1]	lb/1000 bbl	20.09	365.32	306.87	2.19	0.39	0.47	1.18	1.79
2102008000	Industrial Wood [2]	lb/MMBtu	0.017	0.22	0.6	0.025	0.43	0.5	0.017	0.086[3]
2102011000	Industrial Kerosene	lb/1000 gal	0.19	19.29	4.82	142 * S%	0.24	0.96	1.25	0.771
2103001000	Comm/Inst Anthracite Coal	lb/ton	0.3	9	0.6	39 * S%	0.48 * A%	1.1 * A%	0.08	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	0.13	0.32	0.49
2103007000	Comm/Inst LPG	lb/1000 bbl	20.09	365.32	306.87	2.19	0.39	0.47	1.18	1.79
2103008000	Comm/Inst Wood [1]	lb/MMBtu	0.017	0.22	0.6	0.025	0.43	0.5	0.017	0.086[3]
2103011000	Comm/Inst Kerosene	lb/1000 gal	0.33	19.29	4.82	142 * S%	0.8	1.04	1.25	0.771

Source: Unless otherwise noted, 2008 nonpoint source NEI (Huntley, 2009).

Notes: [1] Emission factors from Commercial/Institutional LPG.

[2] Emission factors from *AP-42*, Section 1.6 (Wood Residue Combustion in Boilers).

[3] Emission factor from Pechan, 2004; reported in lb/tons.

In addition to above, PM2.5-PRI and PM10-PRI will be computed as the sum of condensable PM emissions and PM25-FIL/PM10-FIL emissions.

lb = ton
gal = gallon
MMcf = million cubic feet
MMBtu = million British thermal units
bbl = barrels
S = sulfur content
A = ash content

Table 7. Carbon Dioxide Emission Factors for Industrial and Commercial/Institutional Coal Combustion (lb/MMBtu)

State	Industrial CO_2	Commercial/Institutional CO_2
Arkansas	205.70	227.41
Iowa	207.72	204.42
Kansas	203.02	204.89
Louisiana	204.78	227.41
Minnesota	209.70	208.27
Missouri	203.98	204.53
Nebraska	209.66	212.70
Oklahoma	205.99	205.92
Texas	210.39	206.25

Source: EPA State Greenhouse Gas Inventory Tool (EPA, 2009).

Table 8. Additional Greenhouse Gas Emission Factors for ICI Combustion Area Source Categories (lb/MMBtu)

SCC	Description	CO_2	CH_4	N_2O
2102001000	Industrial Anthracite Coal	see above	0.02210	0.00331
2102002000	Industrial Bitum/Subbitum Coal	see above	0.02210	0.00331
2102004000	Industrial Distillate Oil	161.11	0.00663	0.00133
2102005000	Industrial Residual Oil	173.54	0.00663	0.00133
2102006000	Industrial Natural Gas	116.86	0.00209	0.00021
2103007000	Industrial LPG	137.32	0.00663	0.00133
2102008000	Industrial Wood [1]	195	0.06280	0.00837
2102011000	Industrial Kerosene	159.28	0.00663	0.00133
2103001000	Comm/Inst Anthracite Coal	see above	0.02210	0.00331
2103002000	Comm/Inst Bitum/Subbitum Coal	see above	0.02210	0.00331
2103004000	Comm/Inst Distillate Oil	161.11	0.02210	0.00133
2103005000	Comm/Inst Residual Oil	173.54	0.02210	0.00133
2103006000	Comm/Inst Natural Gas	116.86	0.01047	0.00021
2103007000	Comm/Inst LPG	139.00	0.02210	0.00133
2103008000	Comm/Inst Wood [1]	195	0.62802	0.00837
2103011000	Comm/Inst Kerosene	159.28	0.02210	0.00133

Source: Unless otherwise noted, EPA State Greenhouse Gas Inventory Tool (EPA, 2009).
[1] CO_2 emission factors from *AP-42*, Section 1.6 - Wood Residue Combustion in Boilers.

6. Coal Sulfur Content

Under a forthcoming task (Task 4), Pechan will evaluate the reliability of various data sources for coal sulfur content before identifying the source(s) that will be used to estimate emissions in this project. Pechan will review potential coal sulfur content data sources, including:

(1) information reported in the point source inventories of each State;[6] (2) the USGS' U.S. Coal Quality Database (this is the ICI coal sulfur content source used in the 2002 NEI); (3) plant-level data from the Federal Energy Regulatory Commission's (FERC) Form 423;[7] and (4) State-level data reported in EIA's "Monthly Report of Cost and Quality of Fuels for Electric Plants." Pechan will evaluate these and any other identified alternative data sources for use in this project to ensure that the data are as representative as possible with respect to consuming sector, geography, and time-frame. Any data sets that are deemed equally representative will next be evaluated with respect to level of confidence (i.e., a data source for which estimated coal content is based on more data points than other data sources will be deemed to have higher confidence, and therefore, the preferred data source). Pechan will prepare a memorandum identifying the coal content data sources that were reviewed and a priority ranking of preferred sources based on an evaluation of the aforementioned criteria. The memorandum will identify the preferred approach for characterizing the sulfur content of coal consumption for each ICI area source combustion source category, which will be incorporated into the Excel calculation templates.

7. County Allocation Data

After computing State-level emissions using the data described above, the project requires allocating these emissions to individual counties. There are two allocation approaches that CENRAP is evaluating for this step. The first, which has been used in past inventory efforts including the 2002 NEI, is based on each county's proportion of total State employment for the energy-consuming sectors for each source category. The second is based on estimates of total energy consumption for each sector. For both approaches, the initial step is to identify the economic sectors associated with Industrial fuel combustion, and the economic sectors associated with Commercial/Institutional fuel combustion.

Commercial/Institutional

For area source Commercial/Institutional fuel combustion, the 2002 NEI used employment data in North American Industrial Classification System (NAICS) codes 42, 44-45, 51-54, 56, 61-62, 71-72, and 81 to allocate EIA State Commercial sector energy consumption data to counties.[8] These NAICS codes suggest that fuel combustion emissions for the following sectors are covered elsewhere in the NEI: Agriculture, Forestry, Fishing and Hunting; Mining; Construction; Manufacturing; Transportation and Warehousing; Management of Companies and Enterprises; and Public Administration. Meanwhile the EIIP area source method abstracts for Commercial/Institutional fuel combustion categories identify Standard Industrial Classification (SIC) codes 50-99 as representing the Commercial/Institutional sector. These SIC codes indicate that the following is the comprehensive list of non-Commercial sectors: Agriculture, Forestry, Fishing and Hunting; Mining; Construction; Manufacturing; and Transportation, Communications, Electric, Gas, and Sanitary Services.

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[6] Iowa has stated that they did not report coal sulfur content information in their 2002 point source inventory.
[7] Note that these data include Commercial and Industrial combined heat and power producers whose total fossil-fueled nameplate generating capacity is 50 or more megawatts.
[8] These NAICS codes are also listed in ERTAC's area source methodology worksheet (ERTAC, 2009).

Documentation for the SEDS is not entirely clear on the NAICS codes associated with the Commercial sector, defining the Commercial sector as "an energy-consuming sector that consists of service-providing facilities and equipment of: businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The Commercial sector includes institutional living quarters. It also includes sewage treatment facilities." In an attempt to further clarify the NAICS codes associated with this sector, Pechan performed additional research into the original data sources that are used to create the SEDS.

Because data for the SEDS originates with data collected from EIA fuel sector-specific surveys of energy suppliers,[9] Pechan reviewed these survey forms/instructions for further details on what SEDS considers Commercial sector use of each fuel. This review found that the surveys/guidance do not always provide further clarity. In addition, the EIA has admitted that energy suppliers may use their own account classifications as well as EIA guidance in determining whether a particular account belongs in the Residential, Commercial, Industrial, or Transportation sector. 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). With the exception of NAICS code 814 (Private Households), this crosswalk links all NAICS codes between 42 and 92 with Commercial building energy consumption, suggesting that both the EIIP guidance and NEI definitions of the Commercial fuel combustion source category are missing some sectors, while also including one sector that should not be included (Private Households). In lieu of additional information, data for the CBECS-identified NAICS codes (42 though 92 with exception of 814) will be used to allocate SEDS energy consumption data to individual counties.

Industrial

Although there are no EIIP guidance documents for area source Industrial fuel combustion, the 2002 NEI used the Manufacturing sector NAICS codes (31-33) to represent this category. Unlike the Commercial sector, the SEDS documentation provides a clear listing of the NAICS codes associated with SEDS Industrial energy consumption data: "the industrial sector encompasses the following types of activity: Manufacturing (NAICS codes 31–33); Agriculture, Forestry, Fishing and Hunting (NAICS code 11); Mining, including Oil and Gas Extraction (NAICS code 21); and Construction (NAICS code 23)." As noted earlier, this indicates that a portion of Industrial sector consumption is already accounted for in other emission inventory sectors. It is expected that non-Manufacturing sector Industrial fuel consumption will largely be eliminated via the nonroad subtractions described earlier. Therefore, Pechan will not expand the list of NAICS codes used to represent the area source Industrial fuel combustion category beyond the Manufacturing sector NAICS codes (31-33).

<u>Standard Employment-Based Approach</u>

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[9] For natural gas, for example – EIA-176 "Annual Report of Natural and Supplemental Gas Supply and Disposition."

In keeping with EIIP guidance and past EPA practice, employment data can be used to allocate State-level emission estimates to counties. Each year the Census Bureau releases *County Business Patterns* (CBP), a county level data set of employment by NAICS code (Census, 2009). The CBP county-level employment estimates for 2002 can be compiled for the appropriate NAICS codes noted above. Due to concerns with releasing confidential business information, the CBP withholds values for a given county/NAICS code if it would be possible to identify individual businesses from these values. In such cases, the CBP reports a letter code, representing a particular employment size range. To estimate data for withheld counties/NAICS codes, Pechan used the following procedure.

1. County-level employment for counties with reported values are totaled by State for the applicable NAICS code.
2. 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.

Example: NAICS 31-33 (Manufacturing)

fipsstate	fipscty	naics	empflag	emp
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 52,801.
2. The State-level CBP reports 59,322 employees in NAICS 31----the difference is 6,521.
3. 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.

4. State total for these two counties is 19,250.
5. 6,521/19,250 = 0.33875.
6. The final employment estimate for county 015 is 1,750 * 0.33875 = 593. The county 023 final employment estimate is computed as 17,500 * 0.33875 = 5,928.

Energy Intensity-Adjusted Approach

Employment-based county allocation methods lead to overrepresentation of energy consumption in counties with sectors that have high employment but low energy intensities (measured on a Btu per employee basis), and vice-versa. Therefore, Pechan recommended that CENRAP consider utilizing energy use per employee values by NAICS code to refine the employment-based county allocation approach. Because State/NAICS code-level energy use data are not available, this approach relies on 2002 national energy consumption data by NAICS code as reported by EIA in *Annual Energy Outlook* (EIA, 2005). Energy intensity values are computed by dividing these Btu-based energy consumption estimates by 2002 national employment data by NAICS code. The resulting intensity values are then multiplied by county/NAICS code-level employment estimates to estimate total county energy consumption by NAICS code. These values are then summed for the appropriate Industrial and Commercial/Institutional fuel combustion NAICS codes. The resulting county-level total Industrial and total Commercial/Institutional energy consumption estimates can then be used to apportion State-level Industrial fuel combustion emissions and State-level Commercial/Institutional fuel combustion emissions to each county.

Table 9 displays a comparison of the county-level allocation percentages computed for Missouri from the two methods. This table is sorted in descending order based on each county's Industrial fuel combustion employment-based allocation percentage. The cells shaded in green indicate that the energy intensity-adjusted approach reflects a greater than 50 percent higher allocation of activity/emissions to the given county versus the employment-based approach. Similarly, cells shaded in tan indicate that the energy-based approach reflects an allocation that is more than 50 percent lower than that resulting from the employment-based approach. The table shows that the Industrial sector allocations differ more substantially between the two methods in Missouri. Focusing on the Industrial sector allocation percentages for Jackson county, for example, overall Manufacturing sector employment is approximately 10 percent of the Missouri total. However, a much higher percentage of Missouri total Industrial sector energy consumption is estimated for this county (~17 percent). A closer look at the underlying data indicates that this county has a relatively high proportion of total State employment in the Chemicals and Paper industries that are the third and fifth highest energy-intensive manufacturing sector industries. Pechan will provide the information in Table 9 for all CENRAP States when it submits the Task 3 State-level fuel consumption estimates, which are due by April 17.

Table 9. Comparison of County Allocation Approaches for Missouri

County	Industrial				Commercial/Institutional		
	Employment	Energy	Ratio		Employment	Energy	Ratio
St. Louis	17.3%	14.9%	0.9		25.2%	21.8%	0.9
Jackson	10.3%	16.5%	1.6		16.2%	15.2%	0.9
City of St. Louis	8.3%	8.9%	1.1		11.9%	11.4%	1.0
Greene	5.2%	4.5%	0.9		6.0%	6.1%	1.0
St. Charles	4.6%	2.3%	0.5		4.0%	4.1%	1.0
Clay	4.6%	3.4%	0.7		3.3%	3.6%	1.1
Jasper	3.4%	2.5%	0.7		2.0%	2.0%	1.0
Franklin	3.2%	2.5%	0.8		1.0%	1.1%	1.1
Buchanan	2.3%	5.1%	2.2		1.5%	1.5%	1.0
Barry	2.0%	1.3%	0.6		0.4%	0.4%	1.0
Boone	1.7%	0.7%	0.4		2.8%	2.7%	0.9
Pettis	1.6%	1.6%	1.0		0.6%	0.7%	1.2
Cape Girardeau	1.6%	5.5%	3.4		1.6%	1.5%	1.0
Laclede	1.6%	0.4%	0.3		0.3%	0.4%	1.1
Jefferson	1.4%	2.4%	1.7		1.5%	1.8%	1.2
Newton	1.4%	1.2%	0.9		0.5%	0.6%	1.2
Howell	1.2%	0.3%	0.3		0.5%	0.6%	1.2
Cole	1.1%	0.5%	0.4		1.6%	1.5%	0.9
Butler	1.1%	0.4%	0.4		0.6%	0.6%	1.1
Perry	0.9%	0.5%	0.5		0.2%	0.2%	1.0
McDonald	0.9%	0.7%	0.7		0.1%	0.1%	1.3
Marion	0.8%	1.5%	1.8		0.4%	0.5%	1.1
St. Francois	0.8%	1.0%	1.3		0.7%	0.8%	1.0
New Madrid	0.8%	1.7%	2.1		0.1%	0.2%	1.6
Scott	0.8%	0.5%	0.6		0.6%	0.7%	1.1
Stoddard	0.8%	0.4%	0.5		0.3%	0.4%	1.3
Christian	0.7%	0.3%	0.4		0.4%	0.5%	1.2
Nodaway	0.6%	0.6%	1.0		0.3%	0.3%	1.1
Platte	0.6%	0.3%	0.5		1.8%	1.6%	0.9
Audrain	0.6%	0.3%	0.5		0.3%	0.3%	1.1
Phelps	0.6%	0.3%	0.4		0.6%	0.7%	1.3
Linn	0.6%	0.2%	0.4		0.1%	0.2%	1.1
Henry	0.5%	0.3%	0.5		0.2%	0.3%	1.3
Johnson	0.5%	0.3%	0.5		0.4%	0.5%	1.3
Crawford	0.5%	0.2%	0.4		0.2%	0.2%	1.3
Warren	0.5%	0.5%	0.9		0.2%	0.2%	1.1
Ste. Genevieve	0.5%	0.4%	0.8		0.1%	0.2%	1.2
Sullivan	0.5%	0.6%	1.2		0.0%	0.1%	1.4
Barton	0.5%	0.3%	0.6		0.1%	0.2%	1.4
Cass	0.5%	0.5%	1.1		0.7%	0.8%	1.2
Gasconade	0.5%	0.2%	0.5		0.1%	0.2%	1.3
Saline	0.5%	0.4%	0.8		0.3%	0.3%	1.2

County	Industrial				Commercial/Institutional		
	Employment	Energy	Ratio		Employment	Energy	Ratio
Lawrence	0.5%	0.2%	0.5		0.2%	0.4%	1.5
Randolph	0.5%	0.2%	0.5		0.3%	0.4%	1.1
Grundy	0.4%	0.3%	0.7		0.1%	0.2%	1.5
Adair	0.4%	0.2%	0.6		0.3%	0.4%	1.1
Lincoln	0.3%	0.1%	0.4		0.3%	0.4%	1.3
Vernon	0.3%	0.2%	0.4		0.2%	0.3%	1.4
Camden	0.3%	0.1%	0.4		0.6%	0.6%	1.1
Dunklin	0.3%	0.3%	0.8		0.3%	0.4%	1.2
Lafayette	0.3%	0.3%	0.9		0.3%	0.4%	1.2
Osage	0.3%	0.1%	0.4		0.1%	0.1%	1.4
Texas	0.3%	0.2%	0.5		0.2%	0.2%	1.5
Monroe	0.3%	0.1%	0.4		0.1%	0.1%	1.9
Miller	0.3%	0.1%	0.2		0.2%	0.3%	1.2
Webster	0.3%	0.6%	2.2		0.2%	0.2%	1.3
Moniteau	0.3%	0.2%	0.8		0.1%	0.1%	1.3
Callaway	0.3%	0.1%	0.4		0.4%	0.5%	1.2
Pemiscot	0.3%	0.3%	1.2		0.2%	0.2%	1.3
Polk	0.3%	0.1%	0.4		0.3%	0.4%	1.3
Dent	0.2%	0.6%	2.6		0.1%	0.2%	1.2
Livingston	0.2%	0.2%	0.9		0.2%	0.2%	1.2
Washington	0.2%	0.3%	1.3		0.1%	0.2%	1.6
Montgomery	0.2%	0.2%	0.9		0.1%	0.1%	1.4
Pike	0.2%	2.3%	10.5		0.2%	0.2%	1.4
Ripley	0.2%	0.1%	0.6		0.1%	0.1%	1.4
Wright	0.2%	0.1%	0.3		0.1%	0.2%	1.3
Morgan	0.2%	0.1%	0.3		0.1%	0.1%	1.3
Douglas	0.2%	0.1%	0.3		0.1%	0.1%	1.6
Ray	0.2%	0.4%	2.3		0.1%	0.2%	1.4
Cooper	0.2%	0.1%	0.5		0.2%	0.2%	1.3
Taney	0.2%	0.3%	1.5		0.9%	0.9%	1.0
Shannon	0.2%	0.1%	0.5		0.0%	0.0%	1.4
Macon	0.2%	0.3%	1.8		0.1%	0.2%	1.9
Ralls	0.2%	1.6%	10.4		0.1%	0.1%	1.6
Madison	0.2%	0.1%	0.6		0.1%	0.1%	1.3
Wayne	0.1%	0.1%	0.6		0.1%	0.1%	1.3
Dallas	0.1%	0.1%	0.8		0.1%	0.1%	1.0
Carroll	0.1%	0.1%	0.4		0.1%	0.1%	1.4
Bates	0.1%	0.1%	1.3		0.1%	0.2%	1.4
Lewis	0.1%	0.1%	0.5		0.1%	0.1%	1.5
Shelby	0.1%	0.1%	0.7		0.0%	0.1%	2.0
Benton	0.1%	0.1%	1.2		0.1%	0.1%	1.4
Reynolds	0.1%	0.1%	0.8		0.0%	0.1%	1.6
Oregon	0.1%	0.1%	0.8		0.1%	0.1%	1.4
Iron	0.1%	0.0%	0.4		0.1%	0.1%	1.4

County	Industrial				Commercial/Institutional		
	Employment	Energy	Ratio		Employment	Energy	Ratio
Mississippi	0.1%	0.0%	0.3		0.1%	0.1%	1.2
Gentry	0.1%	0.0%	0.3		0.1%	0.1%	1.3
Howard	0.1%	0.2%	2.1		0.1%	0.1%	1.4
Stone	0.1%	0.0%	0.3		0.2%	0.2%	1.2
Carter	0.1%	0.2%	2.7		0.0%	0.0%	1.4
Dade	0.1%	0.0%	0.5		0.1%	0.1%	1.6
Clinton	0.1%	0.0%	0.5		0.2%	0.2%	1.1
Pulaski	0.1%	0.0%	0.2		0.3%	0.4%	1.2
Cedar	0.1%	0.0%	0.5		0.1%	0.1%	1.4
Maries	0.1%	0.5%	8.7		0.1%	0.1%	1.4
Ozark	0.1%	0.0%	0.6		0.0%	0.1%	1.7
Daviess	0.0%	0.0%	0.2		0.0%	0.1%	1.6
Bollinger	0.0%	0.1%	2.3		0.1%	0.1%	1.5
Scotland	0.0%	0.0%	0.5		0.0%	0.1%	2.5
Holt	0.0%	0.2%	4.8		0.0%	0.1%	1.7
Clark	0.0%	0.0%	0.4		0.0%	0.1%	1.8
DeKalb	0.0%	0.2%	4.6		0.1%	0.1%	1.3
Putnam	0.0%	0.0%	1.7		0.0%	0.1%	2.0
Harrison	0.0%	0.0%	0.5		0.1%	0.1%	1.4
Chariton	0.0%	0.0%	0.5		0.1%	0.1%	1.5
Andrew	0.0%	0.0%	0.5		0.1%	0.1%	1.7
Atchison	0.0%	0.0%	0.5		0.1%	0.1%	1.3
Knox	0.0%	0.0%	0.5		0.0%	0.1%	1.8
Hickory	0.0%	0.0%	0.4		0.0%	0.1%	1.7
Worth	0.0%	0.0%	0.4		0.0%	0.0%	2.0
Caldwell	0.0%	0.0%	0.4		0.0%	0.1%	2.1
St. Clair	0.0%	0.0%	0.3		0.1%	0.1%	1.5
Mercer	0.0%	0.0%	0.5		0.0%	0.0%	1.5
Schuyler	0.0%	0.0%	0.2		0.0%	0.0%	2.1

8. Temporal Allocation Data

The EPA provides national default temporal allocation data via the “temporal allocation” section of their Emissions Modeling Clearinghouse (EMCH). For all Industrial sector fuel types, the EPA default is for an equal distribution of annual activity across months. For the Commercial sector, the EPA default is for an equal distribution of annual activity across months for LPG and kerosene, but the EPA default distribution for all other fuel types is as displayed in Table 10.

Table 10. EPA Default Commercial Fuel Combustion Sector Allocation

Month	% Allocation
January	11.7
February	11.7
March	8.3
April	8.3
May	8.3
June	5
July	5
August	5
September	8.3
October	8.3
November	8.3
December	11.7

Note: Excludes LPG and kerosene (equal distribution assumed throughout year).

Pechan researched the availability of more representative (sector, geographic, and/or time-specific) energy consumption data than that used to develop the EMCH's temporal allocation factors. The following summarizes the available information:

- Natural Gas – State-level volume delivered data are available by month and sector (Industrial versus Commercial) for 2002;
- Coal – national consumption data are available by month and sector (Industrial versus Commercial) for 2002; and
- Petroleum products (i.e., distillate, residual, LPG, kerosene) – regional level product supplied data are available by month for 2002.

Pechan was unable to identify a source reporting sub-annual consumption estimates for wood.

Pechan plans to use EIA's State-level natural gas deliveries data for 2002 to allocate the annual SEDS data to each month (EIA, 2009b). Given the limitations of the available coal and petroleum product data, and the lack of data for wood, Pechan plans to apply EPA's monthly default profiles to allocate annual activity/emissions for these fuel types. Because Pechan was unable to identify any source of sub-monthly estimates of ICI energy consumption, the EPA default allocation profiles will be used to develop average weekday, average weekend day, and average weekly emission estimates for each month.

C. CALCULATION TEMPLATES

This section summarizes the draft templates that Pechan has produced to develop the ICI combustion area source emission estimates for CENRAP. CENRAP should not review the actual data in these draft templates at this time because some entries are currently missing or represent "dummy" placeholder values. Pechan will provide completed templates for CENRAP review by April 17 as required under Task 5.

Template 1 – Adjust SEDS Fuel Consumption **–** this workbook, which reflects the discussion in sections B.1 through B.4, performs the following tasks:

- Computes Industrial sector State-level non-fuel energy consumption estimates by fuel type by applying MECS-based non-fuel percentages to the SEDS total Industrial sector energy consumption estimates;
- Subtracts Industrial and Commercial sector State-level distillate and LPG consumption estimates from a (forthcoming) NONROAD model run for 2002.
- Converts the result of the steps above from their original units to the emission factor units;
- Performs the point source subtractions using 2002 CENRAP point source inventory data and the ICI area source combustion SCC to point source SCC crosswalk;

Template 2 – Apply Emission Factors **–** this workbook accompanies the discussion in Sections B.5 and B.6 of criteria pollutant and GHG emission factors and associated coal sulfur content assumptions. Reflecting the fact that some emission factors differ by type of coal, this template also estimates the proportion of Industrial and Commercial/Institutional coal that is anthracite versus bituminous/subbituminous in each State. This template will ultimately report the estimated sulfur content of coal consumed in each State.

Template 3 – County Allocations **–** this workbook, which reflects the Section B.7 discussion, contains the data used to compute both sets of county allocation data (i.e., the county employment data and the total county energy consumption data). This template currently develops actual allocation data for Missouri counties. Ultimately, this template will only include county data for the allocation method that CENRAP chooses to implement in this project. This template also calculates county-level emissions from the Template 2 State-level emission estimates.

Template 4 – Temporal Allocation **–** this workbook, which reflects the discussion in Section B.8, provides the data that will be used to allocate annual county emissions to monthly, average weekly, average weekday, and average weekend day time periods. It will ultimately perform the necessary calculations to estimate emissions in each period.

D. REFERENCES

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ATTACHMENT: PRELIMINARY SUMMARY OF 2002 POINT SOURCE ANNUAL THROUGHPUT DATA

The following table reports 2002 annual point source throughput data associated with the ICI area source categories. The table is sorted in descending order by CENRAP State and area SCC. Cells that are shaded in light blue indicate potentially suspect entries.

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102001000	Industrial	Anthracite Coal	ARKANSAS	1,167,890	TON	640	Anthracite
2102002000	Industrial	Bituminous/Subbituminous Coal	ARKANSAS	3,153,027	TON	663	Bituminous Coal
2102004000	Industrial	Distillate Oil	ARKANSAS	8,255,280	E3GAL	44	Diesel
2102004000	Industrial	Distillate Oil	ARKANSAS	0	E3GAL	57	Distillate Oil (Diesel)
2102004000	Industrial	Distillate Oil	ARKANSAS		E3GAL	58	Distillate Oil (No. 2)
2102004000	Industrial	Distillate Oil	ARKANSAS	2,136,217	E3GAL	823	Distillate Oil (No. 1 & 2)
2102004000	Industrial	Distillate Oil	ARKANSAS	6,408,642	E3GAL	825	Distillate Oil (No. 4)
2102005000	Industrial	Residual Oil	ARKANSAS	224,941	E3GAL	279	Residual Oil
2102005000	Industrial	Residual Oil	ARKANSAS	13,587,658	E3GAL	923	Residual Oil (No. 6)
2102005000	Industrial	Residual Oil	ARKANSAS		E3GAL	924	Residual/Crude Oil
2102006000	Industrial	Natural Gas	ARKANSAS	184,838,095	E6FT3	209	Natural Gas
2102006000	Industrial	Natural Gas	ARKANSAS				
2102007000	Industrial	Liquified Petroleum Gas (LPG)	ARKANSAS		E3GAL	178	Liquified Petroleum Gas (LPG)
2102008000	Industrial	Wood	ARKANSAS	56,092,213	TON	15	Wood
2102008000	Industrial	Wood	ARKANSAS	21,798,710	TON	943	Wood/Bark
2103004000	Commercial/Institutional	Distillate Oil	ARKANSAS		E3GAL	57	Distillate Oil (Diesel)
2103006000	Commercial/Institutional	Natural Gas	ARKANSAS	23,912,086	E6FT3	209	Natural Gas
2103008000	Commercial/Institutional	Wood	ARKANSAS	7,655,765	TON	15	Wood
2102001000	Industrial	Anthracite Coal	IOWA	24	E3GAL	255	Propane
2102001000	Industrial	Anthracite Coal	IOWA	98,368	TON	645	Ash
2102002000	Industrial	Bituminous/Subbituminous Coal	IOWA	30,950,000	LB	561	Sludge
2102002000	Industrial	Bituminous/Subbituminous Coal	IOWA	87,110	TON	323	Subbituminous Coal
2102002000	Industrial	Bituminous/Subbituminous Coal	IOWA	3,741,706	TON	717	Coal
2102004000	Industrial	Distillate Oil	IOWA	1,039	E3GAL	44	Diesel
2102004000	Industrial	Distillate Oil	IOWA	0	E3GAL	56	Distillate Oil
2102004000	Industrial	Distillate Oil	IOWA	926	E3GAL	58	Distillate Oil (No. 2)
2102004000	Industrial	Distillate Oil	IOWA	2	E3GAL	255	Propane
2102004000	Industrial	Distillate Oil	IOWA	42	E3GAL	823	Distillate Oil (No. 1 & 2)
2102004000	Industrial	Distillate Oil	IOWA	0	E3LB	44	Diesel
2102004000	Industrial	Distillate Oil	IOWA	5,599	E6BTU	44	Diesel
2102004000	Industrial	Distillate Oil	IOWA	0	E6BTU	56	Distillate Oil
2102004000	Industrial	Distillate Oil	IOWA	0	E6BTU	209	Natural Gas
2102004000	Industrial	Distillate Oil	IOWA	42	E6BTU	823	Distillate Oil (No. 1 & 2)
2102004000	Industrial	Distillate Oil	IOWA	90	E6FT3	209	Natural Gas

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102004000	Industrial	Distillate Oil	IOWA	8	E6GAL	58	Distillate Oil (No. 2)
2102004000	Industrial	Distillate Oil	IOWA	2	E6GAL	823	Distillate Oil (No. 1 & 2)
2102004000	Industrial	Distillate Oil	IOWA	341,800,000	FT3	209	Natural Gas
2102004000	Industrial	Distillate Oil	IOWA	4,758	GAL	5	Water
2102004000	Industrial	Distillate Oil	IOWA	35,967	GAL	44	Diesel
2102004000	Industrial	Distillate Oil	IOWA	613	GAL	56	Distillate Oil
2102004000	Industrial	Distillate Oil	IOWA	459	GAL	58	Distillate Oil (No. 2)
2102004000	Industrial	Distillate Oil	IOWA	330	GAL	209	Natural Gas
2102004000	Industrial	Distillate Oil	IOWA	10,262	GAL	255	Propane
2102004000	Industrial	Distillate Oil	IOWA	339	GAL	823	Distillate Oil (No. 1 & 2)
2102004000	Industrial	Distillate Oil	IOWA	14,123	HP-HR	58	Distillate Oil (No. 2)
2102004000	Industrial	Distillate Oil	IOWA	2,681	HR	44	Diesel
2102004000	Industrial	Distillate Oil	IOWA	29	HR	209	Natural Gas
2102004000	Industrial	Distillate Oil	IOWA	138	HR	268	Raw Material
2102004000	Industrial	Distillate Oil	IOWA	0	KL	44	Diesel
2102004000	Industrial	Distillate Oil	IOWA	0	TON	44	Diesel
2102004000	Industrial	Distillate Oil	IOWA	0	TON	58	Distillate Oil (No. 2)
2102004000	Industrial	Distillate Oil	IOWA	1,628	TON	268	Raw Material
2102004000	Industrial	Distillate Oil	IOWA				
2102005000	Industrial	Residual Oil	IOWA	14	E3GAL	44	Diesel
2102005000	Industrial	Residual Oil	IOWA	0	E3GAL	923	Residual Oil (No. 6)
2102005000	Industrial	Residual Oil	IOWA	438	E3GAL		
2102005000	Industrial	Residual Oil	IOWA	0	GAL	127	Gasoline
2102005000	Industrial	Residual Oil	IOWA	978,215	GAL	279	Residual Oil
2102005000	Industrial	Residual Oil	IOWA	6,000	GAL	823	Distillate Oil (No. 1 & 2)
2102005000	Industrial	Residual Oil	IOWA	188,565	GAL	923	Residual Oil (No. 6)
2102005000	Industrial	Residual Oil	IOWA				
2102006000	Industrial	Natural Gas	IOWA	6,690	E3FT3	209	Natural Gas
2102006000	Industrial	Natural Gas	IOWA	11	E3GAL	58	Distillate Oil (No. 2)
2102006000	Industrial	Natural Gas	IOWA	18,353,512	E6BTU	209	Natural Gas
2102006000	Industrial	Natural Gas	IOWA	248,378	E6BTU	268	Raw Material
2102006000	Industrial	Natural Gas	IOWA	69,899	E6FT3	127	Gasoline
2102006000	Industrial	Natural Gas	IOWA	2,851,074	E6FT3	209	Natural Gas
2102006000	Industrial	Natural Gas	IOWA	0	E6FT3	225	Paint
2102006000	Industrial	Natural Gas	IOWA	21	E6FT3	268	Raw Material

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102006000	Industrial	Natural Gas	IOWA	119	E6FT3	315	Starch
2102006000	Industrial	Natural Gas	IOWA	0	E6LB	268	Raw Material
2102006000	Industrial	Natural Gas	IOWA	0	E6LB	281	Resin
2102006000	Industrial	Natural Gas	IOWA	1,818,653,437	FT3	209	Natural Gas
2102006000	Industrial	Natural Gas	IOWA	1,335,666,448	FT3S	209	Natural Gas
2102006000	Industrial	Natural Gas	IOWA	1,320	GAL	189	Material
2102006000	Industrial	Natural Gas	IOWA	73,408	GAL	225	Paint
2102006000	Industrial	Natural Gas	IOWA	46	GAL	255	Propane
2102006000	Industrial	Natural Gas	IOWA	0	GAL	268	Raw Material
2102006000	Industrial	Natural Gas	IOWA	4	GAL	952	Solvents: All
2102006000	Industrial	Natural Gas	IOWA	0	GAL	973	ABS Polymer
2102006000	Industrial	Natural Gas	IOWA	30,621	HR	516	Metal
2102006000	Industrial	Natural Gas	IOWA	7,000	LB	189	Material
2102006000	Industrial	Natural Gas	IOWA	0	LB	225	Paint
2102006000	Industrial	Natural Gas	IOWA	13,848	LB	268	Raw Material
2102006000	Industrial	Natural Gas	IOWA	0	LB	281	Resin
2102006000	Industrial	Natural Gas	IOWA	317	LB	516	Metal
2102006000	Industrial	Natural Gas	IOWA	344,238	TON	209	Natural Gas
2102006000	Industrial	Natural Gas	IOWA	14	TON	225	Paint
2102006000	Industrial	Natural Gas	IOWA	40,230	TON	268	Raw Material
2102006000	Industrial	Natural Gas	IOWA	0	TON	289	Sand
2102006000	Industrial	Natural Gas	IOWA	54	TON	303	Soil
2102006000	Industrial	Natural Gas	IOWA	162	TON	315	Starch
2102006000	Industrial	Natural Gas	IOWA	0	TON	561	Sludge
2102006000	Industrial	Natural Gas	IOWA	0	TON	580	Sulfur Dioxide
2102006000	Industrial	Natural Gas	IOWA			209	Natural Gas
2102006000	Industrial	Natural Gas	IOWA				
2102007000	Industrial	Liquified Petroleum Gas (LPG)	IOWA	0	E3GAL	178	Liquified Petroleum Gas (LPG)
2102007000	Industrial	Liquified Petroleum Gas (LPG)	IOWA	0	E3GAL	255	Propane
2102007000	Industrial	Liquified Petroleum Gas (LPG)	IOWA	2,977	E6BTU	209	Natural Gas
2102007000	Industrial	Liquified Petroleum Gas (LPG)	IOWA	0	E6BTU	255	Propane
2102007000	Industrial	Liquified Petroleum Gas (LPG)	IOWA	0	E6FT3	209	Natural Gas
2102007000	Industrial	Liquified Petroleum Gas (LPG)	IOWA	0	E6LB	268	Raw Material
2102007000	Industrial	Liquified Petroleum Gas (LPG)	IOWA	3	E6LB	281	Resin
2102007000	Industrial	Liquified Petroleum Gas (LPG)	IOWA	7,399	GAL	255	Propane

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102007000	Industrial	Liquified Petroleum Gas (LPG)	IOWA				
2102008000	Industrial	Wood	IOWA	13,154	HR	124	Fuel
2102008000	Industrial	Wood	IOWA	6,497	TON	268	Raw Material
2102008000	Industrial	Wood	IOWA	0	TON-YR	717	Coal
2102011000	Industrial	Kerosene	IOWA	0	E3GAL	162	Kerosene
2102011000	Industrial	Kerosene	IOWA	13,717	TON	189	Material
2103002000	Commercial/Institutional	Bituminous/Subbituminous Coal	IOWA	142,485	TON	717	Coal
2103004000	Commercial/Institutional	Distillate Oil	IOWA	26	E3GAL	44	Diesel
2103004000	Commercial/Institutional	Distillate Oil	IOWA	0	E3GAL	56	Distillate Oil
2103004000	Commercial/Institutional	Distillate Oil	IOWA	0	E3GAL	58	Distillate Oil (No. 2)
2103004000	Commercial/Institutional	Distillate Oil	IOWA	18	E3GAL	268	Raw Material
2103004000	Commercial/Institutional	Distillate Oil	IOWA	162	E3GAL	823	Distillate Oil (No. 1 & 2)
2103004000	Commercial/Institutional	Distillate Oil	IOWA	1,033	GAL	44	Diesel
2103004000	Commercial/Institutional	Distillate Oil	IOWA	34,758	GAL	58	Distillate Oil (No. 2)
2103004000	Commercial/Institutional	Distillate Oil	IOWA	0	TON	44	Diesel
2103004000	Commercial/Institutional	Distillate Oil	IOWA				
2103005000	Commercial/Institutional	Residual Oil	IOWA	1	E3GAL	58	Distillate Oil (No. 2)
2103005000	Commercial/Institutional	Residual Oil	IOWA	21	E3GAL		
2103005000	Commercial/Institutional	Residual Oil	IOWA	332,184	GAL	279	Residual Oil
2103005000	Commercial/Institutional	Residual Oil	IOWA	4,340	GAL	923	Residual Oil (No. 6)
2103006000	Commercial/Institutional	Natural Gas	IOWA	51,606	BTU	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	IOWA	719,333	E3FT3	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	IOWA	1	E3GAL	58	Distillate Oil (No. 2)
2103006000	Commercial/Institutional	Natural Gas	IOWA	6	E3GAL	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	IOWA	0	E6BTU	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	IOWA	28	E6FT3	127	Gasoline
2103006000	Commercial/Institutional	Natural Gas	IOWA	28	E6FT3	189	Material
2103006000	Commercial/Institutional	Natural Gas	IOWA	465,334	E6FT3	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	IOWA	16	E6FT3	268	Raw Material
2103006000	Commercial/Institutional	Natural Gas	IOWA	0	E6GAL	823	Distillate Oil (No. 1 & 2)
2103006000	Commercial/Institutional	Natural Gas	IOWA	8,169,622	FT3	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	IOWA	576	GAL	58	Distillate Oil (No. 2)
2103006000	Commercial/Institutional	Natural Gas	IOWA	0	GAL	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	IOWA	831	GAL	255	Propane
2103006000	Commercial/Institutional	Natural Gas	IOWA	24	HR	44	Diesel

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2103006000	Commercial/Institutional	Natural Gas	IOWA	13,632	TON	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	IOWA	0	TON	225	Paint
2103006000	Commercial/Institutional	Natural Gas	IOWA	16,178	TON	724	Coke
2103006000	Commercial/Institutional	Natural Gas	IOWA				
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	IOWA	0	E3GAL	178	Liquified Petroleum Gas (LPG)
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	IOWA	0	E3GAL	255	Propane
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	IOWA	0	E3GAL	268	Raw Material
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	IOWA	15	E6FT3	209	Natural Gas
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	IOWA	0	E6GAL	268	Raw Material
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	IOWA	88,575	GAL	255	Propane
2103008000	Commercial/Institutional	Wood	IOWA	7,142	TON	15	Wood
2102004000	Industrial	Distillate Oil	KANSAS	1,148	E3GAL	44	Diesel
2102004000	Industrial	Distillate Oil	KANSAS	92,275	E3GAL	56	Distillate Oil
2102004000	Industrial	Distillate Oil	KANSAS	83	E3GAL	823	Distillate Oil (No. 1 & 2)
2102004000	Industrial	Distillate Oil	KANSAS	2,437	E3HP-HR	945	Work
2102004000	Industrial	Distillate Oil	KANSAS	22,979	E6BTU	44	Diesel
2102004000	Industrial	Distillate Oil	KANSAS	488	E6BTU	58	Distillate Oil (No. 2)
2102004000	Industrial	Distillate Oil	KANSAS	1,082,040	HP-HR	945	Work
2102004000	Industrial	Distillate Oil	KANSAS	233	HR	209	Natural Gas
2102004000	Industrial	Distillate Oil	KANSAS	716	HR	945	Work
2102004000	Industrial	Distillate Oil	KANSAS	10,248,064	KW-HR	828	Electricity
2102004000	Industrial	Distillate Oil	KANSAS	0			
2102005000	Industrial	Residual Oil	KANSAS	380	E3GAL	922	Residual Oil (No. 5)
2102005000	Industrial	Residual Oil	KANSAS	3,402	E3GAL	923	Residual Oil (No. 6)
2102005000	Industrial	Residual Oil	KANSAS	48	E6BTU	923	Residual Oil (No. 6)
2102006000	Industrial	Natural Gas	KANSAS	287	E3FT3	209	Natural Gas
2102006000	Industrial	Natural Gas	KANSAS	19	E3GAL	189	Material
2102006000	Industrial	Natural Gas	KANSAS	2,594,753	E3HP-HR	945	Work
2102006000	Industrial	Natural Gas	KANSAS	17,010,214	E6BTU	209	Natural Gas
2102006000	Industrial	Natural Gas	KANSAS	282,631	E6FT3	209	Natural Gas
2102006000	Industrial	Natural Gas	KANSAS	39	EACH	189	Material
2102006000	Industrial	Natural Gas	KANSAS	288,425,458	HP-HR	945	Work
2102006000	Industrial	Natural Gas	KANSAS	100	HR	127	Gasoline
2102006000	Industrial	Natural Gas	KANSAS	856,039	HR	209	Natural Gas
2102006000	Industrial	Natural Gas	KANSAS	100,217	HR	945	Work

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102006000	Industrial	Natural Gas	KANSAS	269	LB	209	Natural Gas
2102006000	Industrial	Natural Gas	KANSAS	10,000	LB	635	Ammonia
2102006000	Industrial	Natural Gas	KANSAS	7	TON	209	Natural Gas
2102006000	Industrial	Natural Gas	KANSAS	25	TON	305	Solvent
2102006000	Industrial	Natural Gas	KANSAS	0			
2102007000	Industrial	Liquified Petroleum Gas (LPG)	KANSAS	5	E3GAL	178	Liquified Petroleum Gas (LPG)
2102007000	Industrial	Liquified Petroleum Gas (LPG)	KANSAS	54	E3GAL	178	Liquified Petroleum Gas (LPG)
2102007000	Industrial	Liquified Petroleum Gas (LPG)	KANSAS	0	E3GAL	189	Material
2102007000	Industrial	Liquified Petroleum Gas (LPG)	KANSAS	99	E3GAL	255	Propane
2103004000	Commercial/Institutional	Distillate Oil	KANSAS	22	E3GAL	44	Diesel
2103004000	Commercial/Institutional	Distillate Oil	KANSAS	29	E3GAL	823	Distillate Oil (No. 1 & 2)
2103004000	Commercial/Institutional	Distillate Oil	KANSAS	0			
2103006000	Commercial/Institutional	Natural Gas	KANSAS	3,150	E6FT3	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	KANSAS	0	EACH	189	Material
2103006000	Commercial/Institutional	Natural Gas	KANSAS	107,768	HR	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	KANSAS	7,200	HR	945	Work
2103006000	Commercial/Institutional	Natural Gas	KANSAS	0			
2102002000	Industrial	Bituminous/Subbituminous Coal	LOUISIANA				
2102004000	Industrial	Distillate Oil	LOUISIANA				
2102005000	Industrial	Residual Oil	LOUISIANA				
2102006000	Industrial	Natural Gas	LOUISIANA				
2102007000	Industrial	Liquified Petroleum Gas (LPG)	LOUISIANA				
2102008000	Industrial	Wood	LOUISIANA				
2103004000	Commercial/Institutional	Distillate Oil	LOUISIANA				
2103005000	Commercial/Institutional	Residual Oil	LOUISIANA				
2103006000	Commercial/Institutional	Natural Gas	LOUISIANA				
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	LOUISIANA				
2102002000	Industrial	Bituminous/Subbituminous Coal	MINNESOTA	6,138,274	E6BTU	142	Heat
2102002000	Industrial	Bituminous/Subbituminous Coal	MINNESOTA	10,584	HR	830	Equipment
2102002000	Industrial	Bituminous/Subbituminous Coal	MINNESOTA	582,249	TON	323	Subbituminous Coal
2102002000	Industrial	Bituminous/Subbituminous Coal	MINNESOTA	81,870	TON	663	Bituminous Coal
2102004000	Industrial	Distillate Oil	MINNESOTA	232	E3GAL	44	Diesel
2102004000	Industrial	Distillate Oil	MINNESOTA	4,003	E3GAL	57	Distillate Oil (Diesel)
2102004000	Industrial	Distillate Oil	MINNESOTA	1,071	E3GAL	823	Distillate Oil (No. 1 & 2)
2102004000	Industrial	Distillate Oil	MINNESOTA	535	E3GAL	825	Distillate Oil (No. 4)

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102004000	Industrial	Distillate Oil	MINNESOTA	586	E6BTU	142	Heat
2102004000	Industrial	Distillate Oil	MINNESOTA	1,353,017	GAL	57	Distillate Oil (Diesel)
2102004000	Industrial	Distillate Oil	MINNESOTA	342,565	GAL	823	Distillate Oil (No. 1 & 2)
2102004000	Industrial	Distillate Oil	MINNESOTA				
2102005000	Industrial	Residual Oil	MINNESOTA	362	E3GAL	279	Residual Oil
2102005000	Industrial	Residual Oil	MINNESOTA	370	E3GAL	922	Residual Oil (No. 5)
2102005000	Industrial	Residual Oil	MINNESOTA	21,526	E3GAL	923	Residual Oil (No. 6)
2102005000	Industrial	Residual Oil	MINNESOTA	34,637	E6BTU	142	Heat
2102006000	Industrial	Natural Gas	MINNESOTA	6,400,498	E6BTU	142	Heat
2102006000	Industrial	Natural Gas	MINNESOTA	39,046	E6FT3	209	Natural Gas
2102006000	Industrial	Natural Gas	MINNESOTA	7,395,200	FT3	209	Natural Gas
2102006000	Industrial	Natural Gas	MINNESOTA	19,936,121,225	GAL	209	Natural Gas
2102006000	Industrial	Natural Gas	MINNESOTA	155,328	HR	830	Equipment
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MINNESOTA	94,000	BTU	142	Heat
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MINNESOTA	1,212	E3GAL	255	Propane
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MINNESOTA	209	E3GAL	675	Butane
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MINNESOTA	274	E6BTU	142	Heat
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MINNESOTA	266,584	GAL	255	Propane
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MINNESOTA	626	HR	830	Equipment
2102008000	Industrial	Wood	MINNESOTA	4,675,962	E6BTU	142	Heat
2102008000	Industrial	Wood	MINNESOTA	16,467	HR	830	Equipment
2102008000	Industrial	Wood	MINNESOTA	120,057	TON	15	Wood
2102008000	Industrial	Wood	MINNESOTA	89,216	TON	943	Wood/Bark
2102011000	Industrial	Kerosene	MINNESOTA	12	E3GAL	159	Jet Fuel
2103001000	Commercial/Institutional	Anthracite Coal	MINNESOTA				
2103002000	Commercial/Institutional	Bituminous/Subbituminous Coal	MINNESOTA	2,648	E6BTU	142	Heat
2103002000	Commercial/Institutional	Bituminous/Subbituminous Coal	MINNESOTA	184,324	TON	323	Subbituminous Coal
2103002000	Commercial/Institutional	Bituminous/Subbituminous Coal	MINNESOTA	51,658	TON	663	Bituminous Coal
2103004000	Commercial/Institutional	Distillate Oil	MINNESOTA	1,197	E3GAL	57	Distillate Oil (Diesel)
2103004000	Commercial/Institutional	Distillate Oil	MINNESOTA	1,334	E3GAL	823	Distillate Oil (No. 1 & 2)
2103004000	Commercial/Institutional	Distillate Oil	MINNESOTA	29	E3GAL	825	Distillate Oil (No. 4)
2103005000	Commercial/Institutional	Residual Oil	MINNESOTA	1,695	E3GAL	922	Residual Oil (No. 5)
2103005000	Commercial/Institutional	Residual Oil	MINNESOTA	3,303	E3GAL	923	Residual Oil (No. 6)
2103006000	Commercial/Institutional	Natural Gas	MINNESOTA	8,623,850	E6BTU	142	Heat
2103006000	Commercial/Institutional	Natural Gas	MINNESOTA	19,921	E6FT3	209	Natural Gas

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2103006000	Commercial/Institutional	Natural Gas	MINNESOTA	174,979	HR	830	Equipment
2103006000	Commercial/Institutional	Natural Gas	MINNESOTA				
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	MINNESOTA	3,033	E3GAL	255	Propane
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	MINNESOTA	4,614	E6BTU	142	Heat
2103008000	Commercial/Institutional	Wood	MINNESOTA	1,096	TON	15	Wood
2103008000	Commercial/Institutional	Wood	MINNESOTA	246,551	TON	943	Wood/Bark
2102002000	Industrial	Bituminous/Subbituminous Coal	MISSOURI	20,843	TON	174	Lime
2102002000	Industrial	Bituminous/Subbituminous Coal	MISSOURI	0	TON	189	Material
2102002000	Industrial	Bituminous/Subbituminous Coal	MISSOURI	271,022	TON	663	Bituminous Coal
2102002000	Industrial	Bituminous/Subbituminous Coal	MISSOURI				
2102004000	Industrial	Distillate Oil	MISSOURI	0	E2LB	253	Product
2102004000	Industrial	Distillate Oil	MISSOURI	77,335	E3GAL	44	Diesel
2102004000	Industrial	Distillate Oil	MISSOURI	1,146	E3GAL	56	Distillate Oil
2102004000	Industrial	Distillate Oil	MISSOURI	3,922	E3GAL	57	Distillate Oil (Diesel)
2102004000	Industrial	Distillate Oil	MISSOURI	1,462,931	E3GAL	58	Distillate Oil (No. 2)
2102004000	Industrial	Distillate Oil	MISSOURI	0	E3GAL	352	Toluene
2102004000	Industrial	Distillate Oil	MISSOURI	641	E3GAL	823	Distillate Oil (No. 1 & 2)
2102004000	Industrial	Distillate Oil	MISSOURI	0	E3GAL	825	Distillate Oil (No. 4)
2102004000	Industrial	Distillate Oil	MISSOURI	0	E3GAL	868	Liquid
2102004000	Industrial	Distillate Oil	MISSOURI	0	E3GAL	908	Petroleum Distillate
2102004000	Industrial	Distillate Oil	MISSOURI	27	E3GAL-YR	58	Distillate Oil (No. 2)
2102004000	Industrial	Distillate Oil	MISSOURI	0	E3GAL-YR	127	Gasoline
2102004000	Industrial	Distillate Oil	MISSOURI	10	E3GAL-YR	192	Methanol
2102004000	Industrial	Distillate Oil	MISSOURI	20	E6FT3	209	Natural Gas
2102004000	Industrial	Distillate Oil	MISSOURI	1	E6GAL	4	Wastewater
2102004000	Industrial	Distillate Oil	MISSOURI	0	EACH	364	Unit
2102004000	Industrial	Distillate Oil	MISSOURI	235	MILE	368	Vehicle
2102004000	Industrial	Distillate Oil	MISSOURI	24	TON	133	Grain
2102004000	Industrial	Distillate Oil	MISSOURI	0	TON	174	Lime
2102004000	Industrial	Distillate Oil	MISSOURI	1,462,933	TON	189	Material
2102004000	Industrial	Distillate Oil	MISSOURI	1	TON	189	Material
2102004000	Industrial	Distillate Oil	MISSOURI	13	TON	253	Product
2102004000	Industrial	Distillate Oil	MISSOURI	226	TON	268	Raw Material
2102004000	Industrial	Distillate Oil	MISSOURI	0	TON	311	Soybean Meal
2102004000	Industrial	Distillate Oil	MISSOURI	5	TON	849	Hot Mix Asphalt

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102004000	Industrial	Distillate Oil	MISSOURI				
2102005000	Industrial	Residual Oil	MISSOURI	345	E3GAL	279	Residual Oil
2102005000	Industrial	Residual Oil	MISSOURI	9	E3GAL	922	Residual Oil (No. 5)
2102005000	Industrial	Residual Oil	MISSOURI	1,512	E3GAL	923	Residual Oil (No. 6)
2102005000	Industrial	Residual Oil	MISSOURI	2	E3GAL	924	Residual/Crude Oil
2102005000	Industrial	Residual Oil	MISSOURI	30	TON	174	Lime
2102005000	Industrial	Residual Oil	MISSOURI	0	TON	189	Material
2102005000	Industrial	Residual Oil	MISSOURI	0	TON	849	Hot Mix Asphalt
2102005000	Industrial	Residual Oil	MISSOURI				
2102006000	Industrial	Natural Gas	MISSOURI	84	ACRE-YR	320	Storage Area
2102006000	Industrial	Natural Gas	MISSOURI	0	BALE	740	Cotton
2102006000	Industrial	Natural Gas	MISSOURI	25	E2LB	253	Product
2102006000	Industrial	Natural Gas	MISSOURI	16	E3EACH	654	Batteries
2102006000	Industrial	Natural Gas	MISSOURI	0	E3FT3	189	Material
2102006000	Industrial	Natural Gas	MISSOURI	15	E3GAL	44	Diesel
2102006000	Industrial	Natural Gas	MISSOURI	63	E3GAL	56	Distillate Oil
2102006000	Industrial	Natural Gas	MISSOURI	233	E3GAL	57	Distillate Oil (Diesel)
2102006000	Industrial	Natural Gas	MISSOURI	56	E3GAL	58	Distillate Oil (No. 2)
2102006000	Industrial	Natural Gas	MISSOURI	21	E3GAL	178	Liquified Petroleum Gas (LPG)
2102006000	Industrial	Natural Gas	MISSOURI	24	E3GAL	189	Material
2102006000	Industrial	Natural Gas	MISSOURI	133	E3GAL	255	Propane
2102006000	Industrial	Natural Gas	MISSOURI	123	E3GAL	823	Distillate Oil (No. 1 & 2)
2102006000	Industrial	Natural Gas	MISSOURI	0	E3GAL-YR	58	Distillate Oil (No. 2)
2102006000	Industrial	Natural Gas	MISSOURI	79	E3GAL-YR	127	Gasoline
2102006000	Industrial	Natural Gas	MISSOURI	2	E3GAL-YR	374	Crude Oil
2102006000	Industrial	Natural Gas	MISSOURI	11	E3GAL-YR	865	Jet Kerosene
2102006000	Industrial	Natural Gas	MISSOURI	190	E3GAL-YR	868	Liquid
2102006000	Industrial	Natural Gas	MISSOURI	5,202	E3GAL-YR	908	Petroleum Distillate
2102006000	Industrial	Natural Gas	MISSOURI	254,692	E6FT3	209	Natural Gas
2102006000	Industrial	Natural Gas	MISSOURI	0	EACH	364	Unit
2102006000	Industrial	Natural Gas	MISSOURI	206	EACH	368	Vehicle
2102006000	Industrial	Natural Gas	MISSOURI	97	EACH	712	Circuit Boards
2102006000	Industrial	Natural Gas	MISSOURI	26	GAL	151	Ink
2102006000	Industrial	Natural Gas	MISSOURI	12	GAL	189	Material
2102006000	Industrial	Natural Gas	MISSOURI	9	GAL	305	Solvent

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102006000	Industrial	Natural Gas	MISSOURI	375	GAL	720	Coating
2102006000	Industrial	Natural Gas	MISSOURI	5	MILE	368	Vehicle
2102006000	Industrial	Natural Gas	MISSOURI	32	TON	93	Ethylene Oxide
2102006000	Industrial	Natural Gas	MISSOURI	59	TON	133	Grain
2102006000	Industrial	Natural Gas	MISSOURI	153	TON	174	Lime
2102006000	Industrial	Natural Gas	MISSOURI	1,780	TON	189	Material
2102006000	Industrial	Natural Gas	MISSOURI	456	TON	189	Material
2102006000	Industrial	Natural Gas	MISSOURI	15	TON	224	P2O5
2102006000	Industrial	Natural Gas	MISSOURI	121	TON	253	Product
2102006000	Industrial	Natural Gas	MISSOURI	73	TON	268	Raw Material
2102006000	Industrial	Natural Gas	MISSOURI	2	TON	289	Sand
2102006000	Industrial	Natural Gas	MISSOURI	293	TON	305	Solvent
2102006000	Industrial	Natural Gas	MISSOURI	348	TON	306	Solvent in Coating
2102006000	Industrial	Natural Gas	MISSOURI	65	TON	311	Soybean Meal
2102006000	Industrial	Natural Gas	MISSOURI	0	TON	315	Starch
2102006000	Industrial	Natural Gas	MISSOURI	6	TON	516	Metal
2102006000	Industrial	Natural Gas	MISSOURI	116	TON	516	Metal
2102006000	Industrial	Natural Gas	MISSOURI	0	TON	673	Brick
2102006000	Industrial	Natural Gas	MISSOURI	1	TON	699	Charge
2102006000	Industrial	Natural Gas	MISSOURI	13	TON	723	Coating Mix
2102006000	Industrial	Natural Gas	MISSOURI				
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	4,610	E3GAL	178	Liquified Petroleum Gas (LPG)
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	12,560	E3GAL	255	Propane
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	9	E3GAL-YR	374	Crude Oil
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	122	E3GAL-YR	908	Petroleum Distillate
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	2	E3LB	77	Electrode
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	9	GAL	305	Solvent
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	39	GAL	720	Coating
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	186	MILE	368	Vehicle
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	0	TON	15	Wood
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	0	TON	133	Grain
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	37	TON	189	Material
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	29	TON	268	Raw Material
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	10	TON	291	Sawdust
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	0	TON	306	Solvent in Coating

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	0	TON	723	Coating Mix
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI	0	TON	849	Hot Mix Asphalt
2102007000	Industrial	Liquified Petroleum Gas (LPG)	MISSOURI				
2102008000	Industrial	Wood	MISSOURI	13,640	MILE	368	Vehicle
2102008000	Industrial	Wood	MISSOURI	435,597	TON	15	Wood
2102008000	Industrial	Wood	MISSOURI	366	TON	18	Wood Waste
2102008000	Industrial	Wood	MISSOURI	133,848	TON	943	Wood/Bark
2102011000	Industrial	Kerosene	MISSOURI	115	E3GAL	159	Jet Fuel
2102011000	Industrial	Kerosene	MISSOURI	0	GAL	305	Solvent
2102011000	Industrial	Kerosene	MISSOURI	0	MILE	368	Vehicle
2102011000	Industrial	Kerosene	MISSOURI				
2103002000	Commercial/Institutional	Bituminous/Subbituminous Coal	MISSOURI	20,339	TON	663	Bituminous Coal
2103002000	Commercial/Institutional	Bituminous/Subbituminous Coal	MISSOURI				
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	0	E3GAL	44	Diesel
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	423	E3GAL	56	Distillate Oil
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	1,295	E3GAL	57	Distillate Oil (Diesel)
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	8	E3GAL	127	Gasoline
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	26,744	E3GAL	823	Distillate Oil (No. 1 & 2)
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	6	E3GAL	825	Distillate Oil (No. 4)
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	12	E6FT3	209	Natural Gas
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	0	MILE	368	Vehicle
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	1	TON	180	Logs
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	0	TON	253	Product
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	1	TON	291	Sawdust
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI	0	TON	306	Solvent in Coating
2103004000	Commercial/Institutional	Distillate Oil	MISSOURI				
2103005000	Commercial/Institutional	Residual Oil	MISSOURI	719	E3GAL	279	Residual Oil
2103005000	Commercial/Institutional	Residual Oil	MISSOURI	11	E3GAL	922	Residual Oil (No. 5)
2103005000	Commercial/Institutional	Residual Oil	MISSOURI	32	E3GAL	923	Residual Oil (No. 6)
2103005000	Commercial/Institutional	Residual Oil	MISSOURI	4	E3GAL-YR	58	Distillate Oil (No. 2)
2103005000	Commercial/Institutional	Residual Oil	MISSOURI	2	E6FT3	209	Natural Gas
2103005000	Commercial/Institutional	Residual Oil	MISSOURI				
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	8	ACRE-YR	320	Storage Area
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	125	E3GAL	57	Distillate Oil (Diesel)
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	60	E3GAL	58	Distillate Oil (No. 2)

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	1	E3GAL	127	Gasoline
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	1	E3GAL	305	Solvent
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	282	E3GAL-YR	58	Distillate Oil (No. 2)
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	69	E3GAL-YR	127	Gasoline
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	40,033	E6FT3	209	Natural Gas
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	62	GAL	189	Material
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	141	GAL	720	Coating
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	95	MILE	368	Vehicle
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	30	TON	65	Dried Sludge
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	5	TON	129	Glaze
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	29	TON	133	Grain
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	17	TON	151	Ink
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	0	TON	180	Logs
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	41	TON	189	Material
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	6	TON	224	P2O5
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	16	TON	253	Product
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	355	TON	306	Solvent in Coating
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	39	TON	308	Solvent in Ink
2103006000	Commercial/Institutional	Natural Gas	MISSOURI	8	TON	874	Medical Waste
2103006000	Commercial/Institutional	Natural Gas	MISSOURI				
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	MISSOURI	25	E3GAL	178	Liquified Petroleum Gas (LPG)
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	MISSOURI	24,781	E3GAL	255	Propane
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	MISSOURI	9	E6FT3	209	Natural Gas
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	MISSOURI	1	TON	253	Product
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	MISSOURI				
2103008000	Commercial/Institutional	Wood	MISSOURI	25,448	TON	15	Wood
2103008000	Commercial/Institutional	Wood	MISSOURI	128	TON	943	Wood/Bark
2102002000	Industrial	Bituminous/Subbituminous Coal	NEBRASKA	45,820	TON		
2102004000	Industrial	Distillate Oil	NEBRASKA	137,269	E3GAL		
2102004000	Industrial	Distillate Oil	NEBRASKA				
2102005000	Industrial	Residual Oil	NEBRASKA	268	E3GAL		
2102006000	Industrial	Natural Gas	NEBRASKA	319,058	E3FT3		
2102006000	Industrial	Natural Gas	NEBRASKA	7,733,748	E6FT3		
2102006000	Industrial	Natural Gas	NEBRASKA	232	MASS	1	Waste Material
2102006000	Industrial	Natural Gas	NEBRASKA				

Area_SCC	SCC_2	Area SCC_3	StateName	Throughput	ThroughputUnits	Material Code	Material
2102007000	Industrial	Liquified Petroleum Gas (LPG)	NEBRASKA	48	E3GAL		
2102008000	Industrial	Wood	NEBRASKA	1,141	TON		
2103004000	Commercial/Institutional	Distillate Oil	NEBRASKA	0	E3GAL		
2103006000	Commercial/Institutional	Natural Gas	NEBRASKA	168,142	E6FT3		
2103006000	Commercial/Institutional	Natural Gas	NEBRASKA	22	MASS	1	Waste Material
2103006000	Commercial/Institutional	Natural Gas	NEBRASKA				
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	NEBRASKA	4,866	E3GAL		
2103008000	Commercial/Institutional	Wood	NEBRASKA	9,398	TON		
2102001000	Industrial	Anthracite Coal	OKLAHOMA	645			
2102002000	Industrial	Bituminous/Subbituminous Coal	OKLAHOMA	2,181,492			
2102004000	Industrial	Distillate Oil	OKLAHOMA	25,021			
2102005000	Industrial	Residual Oil	OKLAHOMA	1,463			
2102006000	Industrial	Natural Gas	OKLAHOMA	10,908,513			
2102007000	Industrial	Liquified Petroleum Gas (LPG)	OKLAHOMA	0			
2102008000	Industrial	Wood	OKLAHOMA	114,619			
2103004000	Commercial/Institutional	Distillate Oil	OKLAHOMA	21			
2103006000	Commercial/Institutional	Natural Gas	OKLAHOMA	228,899			
2102002000	Industrial	Bituminous/Subbituminous Coal	TEXAS				
2102004000	Industrial	Distillate Oil	TEXAS				
2102005000	Industrial	Residual Oil	TEXAS				
2102006000	Industrial	Natural Gas	TEXAS				
2102007000	Industrial	Liquified Petroleum Gas (LPG)	TEXAS				
2102008000	Industrial	Wood	TEXAS				
2102011000	Industrial	Kerosene	TEXAS				
2103004000	Commercial/Institutional	Distillate Oil	TEXAS				
2103006000	Commercial/Institutional	Natural Gas	TEXAS				
2103007000	Commercial/Institutional	Liquified Petroleum Gas (LPG)	TEXAS				
2103008000	Commercial/Institutional	Wood	TEXAS				
2103011000	Commercial/Institutional	Kerosene	TEXAS				

Appendix A-6

Inspection/Maintenance Input Table Development Protocol for MOVES for Counties in the St. Louis Ozone Nonattainment Area

EPA has technical guidance on appropriate input assumptions and sources of data for the use of MOVES 2010 in State Implementation Plan (http://www.epa.gov/otaq/models/moves/420b10023.pdf). Section 3.10 of this guidance document explains the appropriate assumptions and methods to be used when developing the I/M input table for MOVES 2010. This guidance has been followed in the development of I/M input Tables 2 – 6 at the end of this document. This document outlines the approach used to develop each parameter of these I/M input tables in MOVES. The goal in developing these I/M input tables is to accurately reflect the actual I/M program being implemented in the St. Louis nonattainment area.

Pollutant Process ID

To begin development of the I/M input table, the default data for the I/M input table for St. Louis County was exported from the MOVES county database manager. The default data included four different I/M test types. However, the actual St. Louis area only had two different test types (On-board diagnostics) OBD tests for the exhaust and evaporative systems. In the default I/M input table, these were the only two types of tests that were "turned on" along with the appropriate pollutant process IDs that would be impacted by each test. Therefore, the pollutant process IDs that were included in the default table for the two OBD tests were the same pollutant process IDs used in the I/M input table for the St. Louis nonattainment area. The other two tests included in the default data along with their associated pollutant process IDs were still included in the I/M input table, but they were "turned off".

Source Type ID

The St. Louis I/M program includes passenger cars and also trucks with a gross vehicle weight rating of 8,500 lbs. or less. Therefore, the three source type IDs included in the I/M input table for the St. Louis nonattainment area are passenger cars, passenger trucks, and light commercial trucks (IDs = 21, 31, and 32).

Fuel Type ID

The St. Louis I/M program is applicable to both gasoline and diesel vehicles; however, MOVES only calculates an I/M benefit for gasoline vehicles. Therefore, the fuel type ID for gasoline was the only uel type ID used in the I/M input table for the St. Louis nonattainment area.

Inspection Frequency

The St. Louis I/M program requires that emission be tested every two years, so the inspection frequency ID that represents biennial tests (ID = 2) was used in the I/M input table for the OBD tests applicable to the St. Louis nonattainment area.

Test Standards

The St. Louis I/M program is a centralized program with OBD tests for exhaust and evaporative systems on the vehicles. Therefore, the test standard IDs for exhaust OBD check and the evaporative system OBD check (IDs = 43 and 51) were used in the I/M input table for the St. Louis nonattainment area.

I/M Program ID

This is an arbitrary number developed by the MOVES user to define a unique test given for vehicles within a range of model years. Therefore, I/M program IDs were arbitrarily assigned to the various unique tests within the St. Louis I/M program.

Beginning and Ending Model Years

The St. Louis I/M program applies to gasoline vehicles with a model year of 1996 or later and it also applies to diesel vehicles with a model year of 1997 or later. Since the emissions inspection is required biennially, the ending model year would always be two years less than the emissions inventory year that is being developed. Therefore, for the tests for gasoline vehicles, the beginning model year is 1996 and the ending model year is two years earlier than the year for which MOVES is being run, and the for diesel vehicles the beginning model year is 1997 and the ending model year is two years earlier than the year for which MOVES is being run.

Compliance Factor

According to page 39 of the MOVES guidance document the compliance factor is calculated with the following equation:

> Compliance Factor = percent compliance rate x (100 – percent waiver rate) x regulatory class coverage adjustment.

Therefore, in order to calculate the compliance factor for each source type included in the I/M program, the compliance rate, waiver rate, and regulatory class coverage adjustment needed to be determined. These three values were determined by the processes described below and then the compliance factors for each source type were calculated with the equation written above.

Compliance Rate

The compliance rate was calculated with the following equation:

> Compliance Rate = Number of vehicles that were tested over a two year period (2008 – 2009) / Population of vehicles that is theoretically subject to I/M during the same period.

In order to determine the compliance rate, as it compares to the source type population by model year, the population of vehicles that is theoretically subject to I/M first needed to be determined.

In May 2009, the Missouri Department of Revenue (DOR) Vehicle Registration database was queried and a VIN decoder was used to separate the vehicle counts into Mobile 6.2 vehicle classes by model year. In the St. Louis nonattainment area, the Mobile 6.2 vehicle classes that are subject to I/M include 1996 and newer light duty gasoline vehicles, light duty gasoline trucks Class 1, light duty gasoline trucks Class 2, light duty gasoline trucks Class 3, light duty gasoline trucks Class 4, as well as 1997 and newer light duty diesel vehicles, light duty diesel trucks Class 1, light duty diesel trucks Class 2, light duty diesel trucks Class 3, and light duty diesel trucks Class 4. Table 1 below shows the total combined population of these 10 vehicle classes within the appropriate model years by county in the St. Louis nonattainment area according the May 2009 DOR data.

Table 1. Vehicles Theoretically Subject to the I/M Program in the St. Louis Nonattainment Area		
	1996 and later	1997 and later
County	**Light Duty Gas (1996 and newer)**	**Light Duty Diesel (1997 and newer)**
Franklin	73,300	328
Jefferson	150,998	484
St Charles	238,672	589
St Louis City	144,871	345
St Louis County	756,978	1,653
Total	**1,364,819**	**3,399**
Total Count	**1,368,218**	

The Air Program also queried the I/M report generator to determine the total number of vehicles, which had their emissions tested at least once from January 1, 2008 through December 31, 2009. The query also included the total number of vehicles that received waivers during the same time period. Table 2 below, was generated with data from this query.

Table 2. Initially Tested Vehicles that Received a Waiver in the St. Louis I/M Program from January 1, 2008 through December 31, 2009

Model Year	Passenger Car			Truck			Total Initially Tested		
	Test Count	Waivers	% Waivers	Test Count	Waivers	% Waivers	Test Count	Waivers	% Waivers
1996	48858	547	1.12 %	5605	61	1.09 %	54463	608	1.12 %
1997	56769	406	0.72 %	8834	50	0.57 %	65603	456	0.70 %
1998	73704	473	0.64 %	8391	63	0.75 %	82095	536	0.65 %
1999	83090	412	0.50 %	12182	46	0.38 %	95272	458	0.48 %
2000	102025	474	0.46 %	10267	44	0.43 %	112292	518	0.46 %
2001	99275	533	0.54 %	13552	57	0.42 %	112827	590	0.52 %
2002	118172	407	0.34 %	11417	18	0.16 %	129589	425	0.33 %
2003	105898	294	0.28 %	14664	24	0.16 %	120562	318	0.26 %
2004	116039	226	0.19 %	11951	16	0.13 %	127990	242	0.19 %
2005	122101	165	0.14 %	13992	20	0.14 %	136093	185	0.14 %
2006	117968	178	0.15 %	10795	21	0.19 %	128763	199	0.15 %
2007	119535	147	0.12 %	11898	18	0.15 %	131433	165	0.13 %
2008	36470	49	0.13 %	2396	3	0.13 %	38866	52	0.13 %
2009	8373	9	0.11 %	396	0	0.00 %	8769	9	0.10 %
2010	129	0	0.00 %	1	0	0.00 %	130	0	0.00 %
Total	1208406	4320	0.36 %	136341	441	0.32 %	1344747	4761	0.35 %

Using the data from Tables 1 and 2 above the compliance rate is calculated for the St. Louis I/M Program with the following equation:

Compliance Rate: (1,344,747 / 1,368,218) x 100% = 98.28%

Waiver Rate

The waiver rate is the percentage of vehicles that fail an initial I/M test and do not pass a retest, but do receive a certificate of compliance. The waiver rate was determined by dividing the number of vehicles that received waivers from January 1, 2008 through December 31, 2009 by the total number of vehicles that were tested at least once during the same time period. Therefore, the waiver rate was calculated for the St. Louis I/M Program with the following equation:

Waiver Rate: (4,761 / 1,344,747) X 100% = 0.35%

Regulatory Class Coverage Adjustment

The regulatory class coverage adjustment is an adjustment that accounts for the fraction of vehicles within a source type that are covered by the I/M program. Since the I/M program in St. Louis exempts vehicles with a gross vehicle weight rating above 8,500 lbs., the compliance factor needs to reflect the percentage of vehicles in the source types subject to I/M that are exempt because of their GVWR. Table A.3 in the Appendix of the MOVES Technical Guidance Document was used to develop adjustments to the compliance factor to account for this discrepancy. The adjustments are percentages of vehicle miles traveled by the various regulatory weight classes within a source type. The corresponding adjustment factors used for the three source categories are as follow:

Passenger cars: 100%
Passenger Trucks: 94%
Light Commercial Trucks: 88%

Calculating the Compliance Factor

Based on the calculations listed above the compliance factor for each source category impacted by the I/M program in St. Louis is listed below.

Passenger cars: 98.28% x (100% - 0.35%) x 100% = **97.94%**
Passenger Trucks: 98.28% x (100% - 0.35%) x 94% = **92.06%**
Light Commercial Trucks: 98.28% x (100% - 0.35%) x 88% = **86.18%**

Appendix B

2008 Base Year Average Winter Day Carbon Monoxide (CO) Emissions Inventory For St. Louis County and St. Louis City

Missouri Department of Natural Resources
Division of Environmental Quality
Air Pollution Control Program
Jefferson City, Missouri

Public Hearing
January 30, 2014

Project Number: 1971-CO-5

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Average Winter Day CO Emissions Inventory Summary

Table B-1
2008 Average Winter Day CO Emissions Inventory Summary for St. Louis County and St. Louis City

Geographic Area	Source Category	2008 CO Emissions (Tons/Average Winter Day)
St. Louis County	Point Sources	13.65
St. Louis County	Area Sources	52.33
St. Louis County	On Road Mobile Sources	425.49
St. Louis County	Off Road Mobile Sources	211.50
St. Louis County	**subtotal**	**702.97**
St. Louis City	Point Sources	3.61
St. Louis City	Area Sources	17.93
St. Louis City	On Road Mobile Sources	106.93
St. Louis City	Off Road Mobile Sources	38.97
St. Louis City	**subtotal**	**167.44**
Total (St. Louis City and County)	Point Sources	17.26
Total (St. Louis City and County)	Area Sources	70.26
Total (St. Louis City and County)	On Road Mobile Sources	532.42
Total (St. Louis City and County)	Off Road Mobile Sources	250.48
Total (St. Louis City and County)	**Total**	**870.42**

* - subtotals may not sum due to rounding

Appendix B-1 2008 Point and Area Source Emissions

The 2008 point source emissions by county for St. Louis County and St. Louis City are summarized below in Table B-2 for an average winter day. The development of the annual point source emissions inventory is detailed in Appendix A, the 2008 Base Year Annual Carbon Monoxide Emissions Inventory for St. Louis county and St. Louis City. The average winter day emissions listed in Table B-2 were developed by dividing the 2008 annual CO emissions from point sources in St. Louis County and St. Louis City and dividing by 366.

Table B-2
2008 Point Source CO Emissions for St. Louis County and St. Louis City

Geographic Area	2008 Point Source CO Emissions (Tons/Average Winter Day)
St. Louis County	13.65
St. Louis City	3.61
Totals	**17.26**

Appendix B-2 2008 Area Source Average Winter Day Emissions

The development of the 2008 annual CO emissions inventory is detailed in Appendix A. In order to calculate average winter day CO emissions for the all area source categories other than residential fuel combustion, the annual emissions were divided by 366. The 2008 average winter day CO emissions for all area source categories by SCC other than residential fuel combustion are listed in Table B-3.

In order to calculate average winter day emissions for residential fuel combustion the Air Program used the EPA's temporal allocation method. A summary of EPA's temporal allocation method can be found in Appendix B-5. The 2008 average winter day CO emissions for all residential fuel combustion source categories by SCC are listed in Table B-4. The average winter day CO emissions inventory summary for all area sources is listed in Table B-5.

When calculating the area source emissions, certain mobile source categories are calculated with methods similar to area sources, particularly marine and rail categories. Although these off road mobile source categories were calculated with area source methodologies, they are not included in the area source inventory listed in Table B-5. The source classification codes (SCCs) pertaining to these off-road mobile sources that were calculated with area source methodologies are listed in Table B-6, and the emissions from these categories are included as off-road mobile source emissions.

Table B-3 2008 Area Source Average Winter Day CO Emissions (Excluding Residential Fuel Combustion)

Geographic Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions (lbs./Average Winter Day)
St. Louis County	2102001000	Stationary Source Fuel Combustion	Anthracite Coal	Industrial	Total: All Boiler Types	-
St. Louis County	2102002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Industrial	Total: All Boiler Types	1,651.20
St. Louis County	2102004000	Stationary Source Fuel Combustion	Distillate Oil	Industrial	Total: Boilers and IC Engines	7.87
St. Louis County	2102005000	Stationary Source Fuel Combustion	Residual Oil	Industrial	Total: All Boiler Types	2.24
St. Louis County	2102006000	Stationary Source Fuel Combustion	Natural Gas	Industrial	Total: Boilers and IC Engines	22.62
St. Louis County	2102007000	Stationary Source Fuel Combustion	Liquefied Petroleum Gas (LPG)	Industrial	Total: All Boiler Types	-
St. Louis County	2102008000	Stationary Source Fuel Combustion	Wood	Industrial	Total: All Boiler Types	1,167.10
St. Louis County	2102011000	Stationary Source Fuel Combustion	Kerosene	Industrial	Total: All Boiler Types	-
St. Louis County	2103001000	Stationary Source Fuel Combustion	Anthracite Coal	Commercial/Institutional	Total: All Boiler Types	-
St. Louis County	2103002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Commercial/Institutional	Total: All Boiler Types	11.48
St. Louis County	2103004000	Stationary Source Fuel Combustion	Distillate Oil	Commercial/Institutional	Total: Boilers and IC Engines	0.11
St. Louis County	2103005000	Stationary Source Fuel Combustion	Residual Oil	Commercial/Institutional	Total: All Boiler Types	-
St. Louis County	2103006000	Stationary Source Fuel Combustion	Natural Gas	Commercial/Institutional	Total: Boilers and IC Engines	60.49
St. Louis County	2103007000	Stationary Source Fuel Combustion	Liquefied Petroleum Gas (LPG)	Commercial/Institutional	Total: All Combustor Types	3.88
St. Louis County	2103008000	Stationary Source Fuel Combustion	Wood	Commercial/Institutional	Total: All Boiler Types	11.75
St. Louis County	2103011000	Stationary Source Fuel Combustion	Kerosene	Commercial/Institutional	Total: All Combustor Types	0.05

Geographic Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions (lbs./Average Winter Day)
St. Louis County	2104002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Residential	Total: All Combustor Types	417.4863
St. Louis County	2104004000	Stationary Source Fuel Combustion	Distillate Oil	Residential	Total: All Combustor Types	5.79235
St. Louis County	2104006000	Stationary Source Fuel Combustion	Natural Gas	Residential	Total: All Combustor Types	2758.251
St. Louis County	2104007000	Stationary Source Fuel Combustion	Liquified Petroleum Gas (LPG)	Residential	Total: All Combustor Types	24.59016
St. Louis County	2104008100	Stationary Source Fuel Combustion	Wood	Residential	Fireplace: general	7475.137
St. Louis County	2104008210	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; non-EPA certified	11727.87
St. Louis County	2104008220	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; non-catalytic	2053.607
St. Louis County	2104008230	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; catalytic	506.5574
St. Louis County	2104008310	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, non-EPA certified	9610.765
St. Louis County	2104008320	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, non-catalytic	1880.109
St. Louis County	2104008330	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, catalytic	464.4262
St. Louis County	2104008400	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: pellet-fired, general (freestanding or FP insert)	213.5519
St. Louis County	2104008510	Stationary Source Fuel Combustion	Wood	Residential	Furnace: Indoor, cordwood-fired, non-EPA certified	2260
St. Louis County	2104008610	Stationary Source Fuel Combustion	Wood	Residential	Hydronic heater: outdoor	4162.131
St. Louis County	2104009000	Stationary Source Fuel Combustion	Firelog	Residential	Total: All Combustor Types	806.1202
St. Louis County	2104011000	Stationary Source Fuel Combustion	Kerosene	Residential	Total: All Heater Types	3.060109
St. Louis County	2302002100	Industrial Processes	Commercial Cooking - Charbroiling	Food and Kindred Products: SIC 20	Conveyorized Charbroiling	123.99

Geographic Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions (lbs./Average Winter Day)
St. Louis County	2302002200	Industrial Processes	Commercial Cooking - Charbroiling	Food and Kindred Products: SIC 20	Under-fired Charbroiling	351.80
St. Louis County	2302003000	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Deep Fat Fying	-
St. Louis County	2302003100	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Flat Griddle Frying	44.92
St. Louis County	2302003200	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Clamshell Griddle Frying	-
St. Louis County Total						**47,829.02**
St. Louis City	2102001000	Stationary Source Fuel Combustion	Anthracite Coal	Industrial	Total: All Boiler Types	-
St. Louis City	2102002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Industrial	Total: All Boiler Types	986.56
St. Louis City	2102004000	Stationary Source Fuel Combustion	Distillate Oil	Industrial	Total: Boilers and IC Engines	4.70
St. Louis City	2102005000	Stationary Source Fuel Combustion	Residual Oil	Industrial	Total: All Boiler Types	1.37
St. Louis City	2102006000	Stationary Source Fuel Combustion	Natural Gas	Industrial	Total: Boilers and IC Engines	11.15
St. Louis City	2102007000	Stationary Source Fuel Combustion	Liquefied Petroleum Gas (LPG)	Industrial	Total: All Boiler Types	-
St. Louis City	2102008000	Stationary Source Fuel Combustion	Wood	Industrial	Total: All Boiler Types	758.14
St. Louis City	2102011000	Stationary Source Fuel Combustion	Kerosene	Industrial	Total: All Boiler Types	-
St. Louis City	2103001000	Stationary Source Fuel Combustion	Anthracite Coal	Commercial/Institutional	Total: All Boiler Types	-
St. Louis City	2103002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Commercial/Institutional	Total: All Boiler Types	11.37
St. Louis City	2103004000	Stationary Source Fuel Combustion	Distillate Oil	Commercial/Institutional	Total: Boilers and IC Engines	0.11
St. Louis City	2103005000	Stationary Source Fuel Combustion	Residual Oil	Commercial/Institutional	Total: All Boiler Types	-

Geographic Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions (lbs./Average Winter Day)
St. Louis City	2103006000	Stationary Source Fuel Combustion	Natural Gas	Commercial/Institutional	Total: Boilers and IC Engines	42.95
St. Louis City	2103007000	Stationary Source Fuel Combustion	Liquefied Petroleum Gas (LPG)	Commercial/Institutional	Total: All Combustor Types	3.33
St. Louis City	2103008000	Stationary Source Fuel Combustion	Wood	Commercial/Institutional	Total: All Boiler Types	12.08
St. Louis City	2103011000	Stationary Source Fuel Combustion	Kerosene	Commercial/Institutional	Total: All Combustor Types	0.05
St. Louis City	2104002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Residential	Total: All Combustor Types	67.06
St. Louis City	2104004000	Stationary Source Fuel Combustion	Distillate Oil	Residential	Total: All Combustor Types	0.85
St. Louis City	2104006000	Stationary Source Fuel Combustion	Natural Gas	Residential	Total: All Combustor Types	178.48
St. Louis City	2104007000	Stationary Source Fuel Combustion	Liquified Petroleum Gas (LPG)	Residential	Total: All Combustor Types	2.32
St. Louis City	2104008100	Stationary Source Fuel Combustion	Wood	Residential	Fireplace: general	440.92
St. Louis City	2104008210	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; non-EPA certified	641.76
St. Louis City	2104008220	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; non-catalytic	137.55
St. Louis City	2104008230	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; catalytic	35.48
St. Louis City	2104008310	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, non-EPA certified	595.41
St. Louis City	2104008320	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, non-catalytic	116.06
St. Louis City	2104008330	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, catalytic	29.04
St. Louis City	2104008400	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: pellet-fired, general (freestanding or FP insert)	14.17
St. Louis City	2104008510	Stationary Source Fuel Combustion	Wood	Residential	Furnace: Indoor, cordwood-fired, non-EPA certified	141.36

Geographic Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions (lbs./Average Winter Day)
St. Louis City	2104008610	Stationary Source Fuel Combustion	Wood	Residential	Hydronic heater: outdoor	260.87
St. Louis City	2104009000	Stationary Source Fuel Combustion	Firelog	Residential	Total: All Combustor Types	53.5
St. Louis City	2104011000	Stationary Source Fuel Combustion	Kerosene	Residential	Total: All Heater Types	0.45
St. Louis City	2302002100	Industrial Processes	Commercial Cooking - Charbroiling	Food and Kindred Products: SIC 20	Conveyorized Charbroiling	44.32
St. Louis City	2302002200	Industrial Processes	Commercial Cooking - Charbroiling	Food and Kindred Products: SIC 20	Under-fired Charbroiling	140.87
St. Louis City	2302003000	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Deep Fat Fying	-
St. Louis City	2302003100	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Flat Griddle Frying	11.80
St. Louis City	2302003200	Industrial Processes	Commercial Cooking - Frying	Food and Kindred Products: SIC 20	Clamshell Griddle Frying	-
St. Louis City Total						**16,866.5**
Combined St. Louis County and St. Louis City Total						**64,695.5**

Table B-4 2008 Average Winter Day CO Emissions for Residential Fuel Combustion

Geographic Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions (lbs./Average Winter Day)
St. Louis County	2104002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Residential	Total: All Combustor Types	952.57
St. Louis County	2104004000	Stationary Source Fuel Combustion	Distillate Oil	Residential	Total: All Combustor Types	13.22
St. Louis County	2104006000	Stationary Source Fuel Combustion	Natural Gas	Residential	Total: All Combustor Types	6,293.46
St. Louis County	2104007000	Stationary Source Fuel Combustion	Liquefied Petroleum Gas (LPG)	Residential	Total: All Combustor Types	24.66
St. Louis County	2104008100	Stationary Source Fuel Combustion	Wood	Residential	Fireplace: general	17,055.89
St. Louis County	2104008210	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; non-EPA certified	26,759.28
St. Louis County	2104008220	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; non-catalytic	4,685.68
St. Louis County	2104008230	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; catalytic	1,155.80
St. Louis County	2104008310	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, non-EPA certified	21,928.72
St. Louis County	2104008320	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, non-catalytic	4,289.81
St. Louis County	2104008330	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, catalytic	1,059.67
St. Louis County	2104008400	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: pellet-fired, general (freestanding or FP insert)	487.26
St. Louis County	2104008510	Stationary Source Fuel Combustion	Wood	Residential	Furnace: Indoor, cordwood-fired, non-EPA certified	5,156.60
St. Louis County	2104008610	Stationary Source Fuel Combustion	Wood	Residential	Hydronic heater: outdoor	9,496.66
St. Louis County	2104009000	Stationary Source Fuel Combustion	Fire log	Residential	Total: All Combustor Types	1,839.31
St. Louis County	2104011000	Stationary Source Fuel Combustion	Kerosene	Residential	Total: All Heater Types	3.07
St. Louis County Total						**101,201.67**
St. Louis City	2104002000	Stationary Source Fuel Combustion	Bituminous/Subbituminous Coal	Residential	Total: All Combustor Types	836.12
St. Louis City	2104004000	Stationary Source Fuel Combustion	Distillate Oil	Residential	Total: All Combustor Types	10.60
St. Louis City	2104006000	Stationary Source Fuel Combustion	Natural Gas	Residential	Total: All Combustor Types	2,225.33
St. Louis City	2104007000	Stationary Source Fuel Combustion	Liquefied Petroleum Gas (LPG)	Residential	Total: All Combustor Types	12.71
St. Louis City	2104008100	Stationary Source Fuel Combustion	Wood	Residential	Fireplace: general	5,497.48

Geographic Area	SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	2008 CO Emissions (lbs./Average Winter Day)
St. Louis City	2104008210	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; non-EPA certified	8,001.60
St. Louis City	2104008220	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; non-catalytic	1,715.00
St. Louis City	2104008230	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: fireplace inserts; EPA certified; catalytic	442.37
St. Louis City	2104008310	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, non-EPA certified	7,423.70
St. Louis City	2104008320	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, non-catalytic	1,447.06
St. Louis City	2104008330	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: freestanding, EPA certified, catalytic	362.08
St. Louis City	2104008400	Stationary Source Fuel Combustion	Wood	Residential	Woodstove: pellet-fired, general (freestanding or FP insert)	176.67
St. Louis City	2104008510	Stationary Source Fuel Combustion	Wood	Residential	Furnace: Indoor, cordwood-fired, non-EPA certified	1,762.51
St. Louis City	2104008610	Stationary Source Fuel Combustion	Wood	Residential	Hydronic heater: outdoor	3,252.58
St. Louis City	2104009000	Stationary Source Fuel Combustion	Fire log	Residential	Total: All Combustor Types	667.05
St. Louis City	2104011000	Stationary Source Fuel Combustion	Kerosene	Residential	Total: All Heater Types	2.47
St. Louis City Total						**33,835.33**
Combined St. Louis County and St. Louis City Total						**135,037.00**

Table B-5
2008 Area Source CO Emissions Summary for St. Louis County and St. Louis City

Geographic Area	2008 Area Source CO Emissions (Tons/Average Winter Day)
St. Louis County	52.33
St. Louis City	17.93
Totals	**70.26**

Table B-6
SCC Codes and Descriptions for Marine and Rail Source Categories Not Included in the Analysis for Area Source Emissions

SCC	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four
2280002100	Mobile Sources	Diesel	Marine Vessels, Commercial	Port emissions
2280002200	Mobile Sources	Diesel	Marine Vessels, Commercial	Underway emissions
2285002006	Mobile Sources	Diesel	Railroad Equipment	Line Haul Locomotives: Class I Operations
2285002007	Mobile Sources	Diesel	Railroad Equipment	Line Haul Locomotives: Class II / III Operations

Appendix B-3 On-Road Mobile Source Emissions

EPA released the Mobile Vehicle Emission System (MOVES) in December of 2010, and MOVES is now the official model to use for mobile emissions modeling. Annual 2008 mobile emissions were initially created using Mobile6.2 via the National Mobile Inventory Model (NMIM) for Missouri for the purpose of submitting state wide emissions data for EPA's 2008 National Emissions Inventory (NEI). The NMIM National County Database (NCD) was updated with Missouri specific data. Local vehicle miles traveled (VMT) data, vehicle registration distributions, and meteorology data from the updated NCD were converted to MOVES formatting using EPA provided conversion workbooks.

The emissions for 2008 were calculated using 2008 VMT data provided by the East West Gateway Council of Governments. The 2008 VMT data was originally generated from the Missouri Department of Transportation for state-owned roads, and then East-West Gateway used their Traffic Demand Model to calculate the actual local VMT data for each of the five counties on the Missouri side of the St. Louis Ozone nonattainment area.

The road type distribution in the baseyearvmt table from the NCD was used to distribute the county level VMT to road type. EPA's VMT converter workbook was then used to produce MOVES input tables. A vehicle registration distribution was originally created for NMIM using registration data from Missouri's Department of Revenue. The vehicle distribution was converted to MOVES age distribution table using EPA's VMT converter workbook. The registration data was also used to create the MOVES vehicle population input tables. Vehicle counts were converted from Mobile 6.2 vehicle classes to MOVES source types using the source type fractions from the Source Type Pop Fractions table in EPA's VMT converter workbook.

St. Louis City and St. Louis County both participate in the Gateway Vehicle Inspection Program (GVIP). For counties subject to Emission Inspection/Maintenance (I/M) Programs, MOVES allows for an I/M input table to be created to describe the program in those counties. An I/M input table was created to describe the GVIP for St. Louis City and St. Louis County. Development of the table was in accordance with EPA technical guidance on appropriate input assumptions and sources of data for the use of MOVES 2010 in State Implementation Plans (http://www.epa.gov/otaq/models/moves/420b10023.pdf). Documentation for the development protocol for the I/M input table can be found in Appendix A-6.

MOVES base data was used for all other inputs, after reviewing the data to ensure accuracy. The base fuel supply tables in MOVES were used for the runs, as they already took into account the reformulated gasoline used in the St. Louis nonattainment area. A separate input database was created for each county, using county specific data where possible. All of the MOVES input tables, other than templates where EPA default data was used, which were used to create the 2008 on-road mobile emissions inventory referred to in Section 3 of this CO Limited Maintenance Plan can be found in Appendix A.

The MOVES model runs were set up selecting all available gasoline and diesel fuel vehicle type combinations, all months, days, hours, and all road types. A separate run was set-up for St. Louis

County and St. Louis City. The emissions were post-aggregated to the month level using MOVES.

Once MOVES input tables had been created, MOVES 2010a was run and all months for 2008 were selected to create an annual emissions profile. The emissions for the months of December, January, February, and March were totaled and divided by 122 days (2008 was a leap year), the number of days in those months, to give average winter day emissions

Table B-7 summarizes the 2008 on-road emissions for the months of December, January, February, and March as calculated using MOVES 2010A for St. Louis County and St. Louis City. Table B-8 summarizes the average winter day emissions of CO for St. Louis County and St. Louis City. All of the MOVES inputs that were used to create the 2008 annual on-road mobile emissions inventory that were then used to generate the average winter day emissions can be found in Appendix A.

Table B-7
2008 On-Road Mobile Source Winter Month CO Emissions
for St. Louis County and St. Louis City

Geographic Area / Month	2008 On Road Mobile Source CO Emissions (Tons)
St. Louis County / January	15,077.55
St. Louis County / February	12,011.11
St. Louis County / March	11,845.30
St. Louis County / December	12,975.47
St. Louis County (Winter Total)	**51,909.43**
St. Louis City / January	3,767.59
St. Louis City / February	3,008.64
St. Louis City / March	3,014.92
St. Louis City / December	3,254.01
St. Louis City (Winter Total)	**13,045.15**

Table B-8
2008 On-Road Mobile Source Average Winter Day CO Emissions
for St. Louis County and St. Louis City

Geographic Area	2008 On Road Mobile Source CO Emissions (Tons/Average Winter Day)
St. Louis County	425.49
St. Louis City	106.93
Totals	**532.42**

Appendix B-4 2008 Off-Road Mobile Source Emissions

The Air Program Staff followed the 2008 and 2022 modeling protocol submitted by EPA Region 7 to the Department for the development of the 2008 off-road mobile emissions with some exceptions. The Staff used 3.5% oxygen weight instead of 0.35% and 100% ethanol blend market instead if 10%. The EPA Region VII modeling protocol for 2008 and 2022 Off-Road Mobile Source Emissions in the St. Louis Nonattainment area can be found in Appendix B-6 of this document. The data generated by the Air Program Staff for the 2008 off-road mobile source emissions for St. Louis County and St. Louis City is summarized in Table B-9.

Due to the methods that are used to calculate the emissions for the marine and rail categories, these categories are sometimes included as area source emissions, although they really should be classified as off-road mobile source emissions. Therefore, the emissions for rail and marine are not included in the total area source emissions. The 2008 emissions for marine, rail, and air sources are summarized for St. Louis County and St. Louis City in Table B-10. The total 2008 off-road mobile source emissions for St. Louis County and St. Louis City are listed in Table B-11.

Table B-9
2008 Off-Road Mobile Source Emissions for St. Louis County and St. Louis City
(Tons/Average Winter Day)

Area	CO
St. Louis County	207.36
St. Louis City	38.26
Totals	**245.62**

Table B-10
2008 Marine, Rail, and Air Emissions for St. Louis County and St. Louis City
(Tons/Winter Day)

Area	CO
St. Louis County	4.15
St. Louis City	0.72
Totals	**4.86**

Table B-11
Total 2008 Off-Road Mobile Source Emissions for St. Louis County and St. Louis City
(Tons/Winter Day)

Area	CO
St. Louis County	211.50
St. Louis City	38.98
Totals	**250.48**

Appendix B-5 Temporal Allocation Methodology Applied to Residential Fuel Combustion Area Source Categories

The procedures summarized in this Appendix are based on the April 29, 2002 memorandum from Gregory Stella, U.S. EPA, "Temporal Allocation of Annual Emissions using EMCH Temporal Profiles" (http://www.epa.gov/ttn/chief/emch/temporal/temporal_factors_042902.pdf).

Area Source categories for residential fuel combustion were calculated on an annual basis for 2008. Because residential fuel combustion takes place primarily in the winter months, as opposed to simply dividing the annual emissions by 365 to get average winter day emissions, these annual emissions were multiplied by a temporal allocation factor for an average day in January through the following calculation steps:

The first step is to determine the monthly profile for the particular source classification code using EPA's temporal cross reference file which can be found at the following website: http://www.epa.gov/ttnchie1/emch/temporal/. The next step is to correlate the monthly profile to a monthly profile factor for the month of interest as well as a total monthly profile factor using EPA's temporal profile document, which can be found at the same website. In order to calculate the fraction of annual emissions for a particular month (January), the monthly profile factor for a specific month is divided by the total monthly profile factor:

Fraction of Annual Emissions for January = (January Profile Factor / Total Monthly Factor)

Then, in order to calculate the temporal allocation factor for an average monthly day, an average day per year is used in the calculation because the monthly profile factors are not weighted for the specific number of days in each month. So the temporal allocation factor for an average January day is calculated as follows:

Temporal Allocation Factor for an Average Day in January =
(Fraction of Annual Emissions for January) / (Days per Year (365) / Months per Year (12))

Example:

Residential Bituminous/Subbituminous Coal Combustion (SCC = 2104002000)

Monthly Profile for SCC 2104002000 = 485

Monthly Profile 485:
    January Monthly Profile Factor = 190
    Total Monthly Profile Factor = 1002

Fraction of Annual Emissions for January = 190 / 1002 = 0.189621

Temporal Allocation Factor for an Average Day in January = (0.189621) / (365 / 12) = 0.0062341

This temporal allocation factor can then be multiplied by the annual emissions of this SCC in order to calculate the emissions of this SCC for an average January day. Table B-12 gives the monthly profiles and the profile factors for all residential fuel combustion SCCs along with the calculated temporal allocation factors for an average January day.

Table B-12 Calculation of Average January Day Temporal Allocation Factors for Residential Fuel Combustion SCCs

SCC	Monthly Profile #	January Monthly Profile Factor	Total Monthly Profile Factor	Temporal Allocation Factor for an Average January Day
2104002000	485	190	1002	0.0062341
2104004000	485	190	1002	0.0062341
2104006000	485	190	1002	0.0062341
2104007000	262	83	996	0.0027397
2104008100	485	190	1002	0.0062341
2104008210	485	190	1002	0.0062341
2104008220	485	190	1002	0.0062341
2104008230	485	190	1002	0.0062341
2104008310	485	190	1002	0.0062341
2104008320	485	190	1002	0.0062341
2104008330	485	190	1002	0.0062341
2104008400	485	190	1002	0.0062341
2104008510	485	190	1002	0.0062341
2104008610	485	190	1002	0.0062341
2104009000	485	190	1002	0.0062341
2104011000	262	83	996	0.0027397

Appendix B-6 EPA Region 7 Off-Road Emissions Modeling Protocol for 2008 and 2022 for the St. Louis, Missouri-Five County Nonattainment Area

For this modeling exercise, the EPA Region 7 utilized the NONROAD2008a model to calculate an ozone and PM2.5 nonroad inventory in five counties in the St. Louis nonattainment area for the 1997 PM2.5 annual and 1997 Ozone NAAQS. The NONROAD2008a model provides the emissions for all nonroad source categories except aircraft, commercial marine vessel, and railroad locomotive.

In running the NONROAD model, the user must specify a modeling scenario by the inventory year, geographic area (nation, state, county), period (annual, seasonal, monthly, daily), and the equipment categories. For all other required variables, the NONROAD model provides default input values. For the following modeling exercises, fuel parameters (Reid Vapor Pressure (RVP), oxygen weight, sulfur content, ethanol volume and market percentage) and temperatures for each geographical area were provided by MDNR in lieu of the modeling default settings for more accurate results (see attachment).

<u>Ozone Precursor Emissions</u>

Ozone Methodology/Input Data

Nonroad mobile source emissions for the years of 2008 and 2022 are calculated using the EPA approved model, NONROAD2008a, and included Franklin County, Jefferson County, St. Charles County, St. Louis County and St. Louis City in St. Louis, Missouri.
For modeling ozone precursor pollutants, temperatures and fuel characteristics representative of each county during an ozone summer weekday, were entered into NONROAD2a and modeled to calculate an ozone season weekday emissions for nonroad sources. Minimum, maximum, and average temperatures for a typical summer season were provided by MDNR (see attachment). Modeling input parameters are as follows:

Table B-13
NONROAD Model Temperature & Fuel Characteristic Input Values by County

County	Oxygen Weight %	RVP psi	Gasoline Sulfur %	Diesel Sulfur	Marine Diesel Sulfur %	CNG / LPG Sulfur %	Temperatures		
							Min.	Max.	Avg.
Franklin	0.35	7	0.0049	0.0355	0.0402	0.003	61.8	90	75.96
Jefferson	0.35	7	0.0049	0.0355	0.0402	0.003	61	88.6	75.16
St. Charles	0.35	7	0.0049	0.0355	0.0402	0.003	62.2	89.2	76.15
St. Louis	0.35	7	0.0049	0.0355	0.0402	0.003	64.1	89.5	77.1
St. Louis City	0.35	7	0.0049	0.0355	0.0402	0.003	65.1	89.8	77.72

Direct $PM_{2.5}$ / $PM_{2.5}$ Precursor Emissions

Methodology/Input Data

Nonroad mobile source emissions for the years of 2008 and 2022 were calculated using the EPA approved model, NONROAD2008a, and included Franklin County, Jefferson County, St. Charles County, St. Louis County and St. Louis City in St. Louis, Missouri.

For modeling $PM_{2.5}$ and $PM_{2.5}$ precursor pollutants, temperatures and fuel characteristics representative of each county for each of the four seasons (winter, spring, summer, and fall) were entered into the NONROAD2008a model as input parameters. The highest temperature and lowest temperature from each three month period (December-February, March-May, June-August, and September-November) were averaged to create a seasonal average temperature. Those seasonal average temperatures, seasonal minimum and seasonal maximum temperatures were then utilized in the model, including the fuel parameters, to calculate the total emissions for each county and season. Summing the emissions of all four seasons for each county gave the total annual emissions. The temperatures and fuel characteristics representative of each county were provided by MDNR. Modeling input parameters are as follows:

Table B-14
NONROAD Model Temperature & Fuel Characteristic Input Values by County & Season

County	Season	Oxygen Weight %	RVP psi	Gasoline Sulfur %	Diesel Sulfur	Marine Diesel Sulfur %	CNG / LPG Sulfur %	Temperatures		
								Min.	Max.	Avg.
Franklin	Winter	0.35	11.5	0.0043	0.0355	0.0402	0.003	19.7	47	33.4
Franklin	Spring	0.35	9	0.0046	0.0355	0.0402	0.003	33.5	76.9	55.2
Franklin	Summer	0.35	7	0.0049	0.0355	0.0402	0.003	61.8	90	75.9
Franklin	Autumn	0.35	9	0.0046	0.0355	0.0402	0.003	34.3	80.9	57.6
Jefferson	Winter	0.35	11.5	0.0043	0.0355	0.0402	0.003	18.6	45.6	32.1
Jefferson	Spring	0.35	9	0.0046	0.0355	0.0402	0.003	32.4	75.8	54.1
Jefferson	Summer	0.35	7	0.0049	0.0355	0.0402	0.003	61	88.6	74.8
Jefferson	Autumn	0.35	9	0.0046	0.0355	0.0402	0.003	33.6	79.8	56.7
St. Charles	Winter	0.35	11.5	0.0043	0.0355	0.0402	0.003	18.7	43.9	31.3
St. Charles	Spring	0.35	9	0.0046	0.0355	0.0402	0.003	32.3	75.8	54.1
St. Charles	Summer	0.35	7	0.0049	0.0355	0.0402	0.003	62.2	89.2	75.7
St. Charles	Autumn	0.35	9	0.0046	0.0355	0.0402	0.003	34.8	80.3	57.6
St. Louis	Winter	0.35	11.5	0.0043	0.0355	0.0402	0.003	19.8	44.2	32
St. Louis	Spring	0.35	9	0.0046	0.0355	0.0402	0.003	34.5	76.1	55.3
St. Louis	Summer	0.35	7	0.0049	0.0355	0.0402	0.003	64.1	89.5	76.8
St. Louis	Autumn	0.35	9	0.0046	0.0355	0.0402	0.003	35.5	80.2	57.9
St. Louis City	Winter	0.35	11.5	0.0043	0.0355	0.0402	0.003	20.7	45.5	32.6
St. Louis City	Spring	0.35	9	0.0046	0.0355	0.0402	0.003	35.7	76.4	56
St. Louis City	Summer	0.35	7	0.0049	0.0355	0.0402	0.003	65.1	89.8	77.5
St. Louis City	Autumn	0.35	9	0.0046	0.0355	0.0402	0.003	36.6	80.4	58.5

QA/QC

Quality control and quality assurance were conducted throughout this nonroad modeling process. Data collected from various data sources were verified and correctly entered or transcribed into the model. In some instances, input values, i.e., temperatures and fuel values were double and/or triple checked for accuracy to insure they corresponded to the data supplied by MDNR. In addition, a spot-checking of the modeling results, including rerunning the model for those results in question, was performed to insure reliability.