3.0 EMISSIONS MODELING

3.1 SOURCES OF EMISSIONS

The process of producing a model-ready inventory is iterative, with data corrections or improvements invariably leading to a succession of more refined modeling inventories. All emission inventories corrections and improvements from St. Louis 8-Hour Ozone modeling were implemented in the PM2.5 modeling. The St. Louis modeling commenced with Base 1 and concluded with Base 5, and the latter reflects processing of Midwest RPO inventory updates through the Base K inventory, CENRAP inventory updates through the Base G, VISTAS Base G emissions for the VISTAS states, and emission updates for the St. Louis NAA and the remainder of Missouri and Illinois from the MDNR and IEPA. Below is a summary of the most significant changes from the Base 1 through the final Base 5 versions of the modeling inventories.

Base 1 Modeling Emissions Inventory

- CENRAP Base A inventory for all source categories plus continuous emissions model (CEM) data for all CENRAP EGUs
- MRPO Base I inventory for all categories
- Initial draft link-based Vehicle Miles Traveled (VMT) from East-West Gateway

Base 2 Modeling Emissions Inventory

- CENRAP Base B inventory for all source categories (no changes to CEM data)
- Corrected MO statewide recreational marine emissions in the offroad inventory
- MRPO Base J inventory for all categories except onroad mobile
- Draft link-based VMT from East-West Gateway received Aug 2005 (~84 million DVMT total in counties covered by network)

Base 3 Modeling Emissions Inventory

- Draft MRPO Base K emissions for aircraft, commercial marine, locomotives for MRPO states (categories were missing from MRPO Base J)
- "Final" link-based VMT from East-West Gateway received Oct 2005 (~70 million DVMT total)

Base 3b Modeling Emissions Inventory

- Corrected point source stack parameters in MRPO States
- Refined criteria for elevated and plume-in-grid (PiG) sources and set PiG sources consistently across all episodes
- Reran biogenics and onroad mobile for July episode using "Base 2" meteorological inputs

Base 4 Modeling Emissions Inventory

- MRPO Base K inventory for all categories except onroad mobile
- Added portable fuel containers (gas cans) to MO area inventory statewide
- Corrected aircraft refueling emissions at Lambert International Airport (applied a 90% control factor)

- Corrected VOC emissions at a point source in Arkansas -- 52,000 tons/yr changed to 52 tpy

Base 5 Modeling Emission Inventory

- CENRAP Base G for EGUs and NEGUs
- VISTAS Base G for EGUs and NEGUs

MDNR, IEPA, and ENVIRON/Alpine collaborated on preparing the emissions. IEPA used EMS-2003 to process the emissions for electric EGUs for the MRPO States plus Minnesota.[1] ENVIRON/Alpine generated biogenic and onroad mobile emissions, and MDNR prepared emissions for the remainder of the source categories. Both ENVIRON/Alpine and MDNR used Sparse Matrix Operator Kernel Emissions (SMOKE) v.2.1 as their emissions processing tool. MDNR, IEPA, and ENVIRON/Alpine were all involved in quality-assuring the raw emissions inputs as well as the gridded, model-ready emissions files.

3.1.1 2002 BASE 5 TYPICAL EMISSION INVENTORY (MODEL VALIDATION INVENTORY)

The 2002 Base 5 model validation inventory was used for the CMAQ and CAMx models performance evaluations. Unlike the Ozone SIP inventory, this inventory does not include CEM emissions data to calibrate the two models.

3.1.1.1 ALL POINT SOURCES EXCEPT EGUs IN MIDWEST RPO AND MINNESOTA

For the majority of point sources in the modeling domain, MDNR obtained emissions inventory files in SMOKE's inventory data analyzer (IDA) format from the RPOs. In order to facilitate future-year emissions processing, each of the IDA files was separated into EGUs, defined as sources included in the Integrated Planning Model (IPM), and non-EGUs, defined as sources not included in IPM. Because 2009 and 2012 outputs from IPM were used for future-year emissions for EGUs, extracting these sources before applying growth and control factors to the non-EGUs ensured that EGU emissions were not double-counted in 2009 and 2012. The EGUs and non-EGUs were separated using a crosswalk obtained from the MRPO that linked inventory identifiers (state and county codes, facility IDs, emission unit IDs, process IDs, and Source Classification Codes (SCCs)) to the corresponding identifiers used in the IPM model.

For the MRPO States and Minnesota[1], non-EGU point source inventory files were obtained from the MRPO in the National Emissions Inventory format (NIF). The NIF files were converted to SMOKE-compatible formats. The department compared the MRPO emissions generated using SMOKE to Base K emissions reports posted on the Lake Michigan Air Directors Consortium (LADCO) emissions modeling webpage (http://www.ladco.org/tech/emis/basek/BaseK_Reports.htm). Results that were very similar to LADCO's were achieved by using a combination of IDA-formatted files and files in SMOKE's day-specific format (ptday). This was done by converting annual emissions records in the original NIF files to the IDA format and converting the summer day emissions records to the ptday format. When an IDA file is used in

1 Minnesota, though a CENRAP member state, was actively involved with the MRPO in reviewing and revising its inventory beyond CENRAP's contractor-supported base year inventory. Minnesota gave approval to the MRPO for using these updates in their emissions processing, and this lead was generally followed for Minnesota's emissions for the St. Louis study.

conjunction with a ptday file, SMOKE selects the emissions values representing the most specific time period for any given source, i.e., daily emissions are selected over annual emissions.

In addition to the traditional point sources, CENRAP, WRAP, and VISTAS provided a set of files containing emissions and plume rise data for prescribed burning and wildfires that could be temporally and spatially resolved. These fires were processed as point sources within the SMOKE modeling system.

Table B-1 in Appendix B1 shows all of the raw point source inventory input files used in MDNR's SMOKE processing, including the geographic coverage of the inventory, the pollutants included, the source of the original inventory data files, and a summary of any modifications made to the original files for the St. Louis modeling effort.

3.1.1.2 EGU POINT SOURCES IN MIDWEST RPO and MINNESOTA

Unit-specific EGU temporal profiles based on median monthly CEM heat input data for the years 2000-2003 were developed by the MRPO that account for monthly and day-of-week variations in emissions. The Midwest RPO provided this inventory refinement in the form of NIF-formatted hourly EGU emissions records that were directly readable by EMS. The department converted the NIF-formatted records to a format readable by SMOKE.

3.1.1.3 AREA SOURCES

For the majority of area sources in the modeling domain, MDNR obtained emissions inventory files in SMOKE's IDA format from the RPOs. For the MRPO states and Minnesota, area source inventory files were obtained from the MRPO in the NIF format and they were converted to SMOKE-compatible formats by the department. The emissions results generated using SMOKE for the MRPO states were compared to the Base K inventory reports posted on LADCO's emissions modeling webpage (http://www.ladco.org/tech/emis/basek/BaseK_Reports.htm). Results most comparable to LADCO's were achieved using a combination of IDA-formatted files and SMOKE's EMS-95 format. The annual emissions contained in the original NIF files were converted to IDA, and the typical day emissions records were converted to SMOKE's EMS-95 format. As opposed to daily emissions values contained in an IDA-formatted file, SMOKE does not "annualize" daily emissions contained in EMS-95 formatted file by multiplying the value by 365 before applying monthly temporal profiles. The EMS-95 formatted files were processed separately and merged with the rest of the area source emissions.

Table B-2 in Appendix B1 shows all inventory files used in the department's area source SMOKE processing, including the geographic coverage, the pollutants included, the source of the original file, and any revisions made to the original files for the St. Louis modeling. The table also indicates which area source inventory files include agricultural and other prescribed burning activities, which are particularly significant in Kansas and Oklahoma.

3.1.1.4 OFFROAD MOBILE SOURCES

For the majority of the modeling domain, the department obtained offroad mobile emissions inventory files in IDA format from the (RPOs). For the MRPO states and Minnesota, offroad inventory files were obtained from the MRPO in NIF format and converted to SMOKE's IDA format.

Table B-3 in Appendix B1 shows all inventory files used in the department's 2002 offroad mobile source SMOKE processing, including the geographic coverage, the pollutants included, the source of the original file, and any revisions made to the original files for the St. Louis study.

3.1.1.5 ONROAD MOBILE SOURCES

The category of on-road mobile source emissions includes emissions from vehicles certified for highway use: cars, trucks, and motorcycles. Emissions from these vehicles were estimated within the SMOKE model, which relies upon MOBILE6 to generate emission factors. For eight St. Louis non-attainment area counties with a transportation network modeled by EW Gateway, detailed emissions were estimated using link-level inputs within SMOKE. For the rest of the counties in each domain, county-level VMT data were obtained from the CENRAP Base B modeling effort and the MWRPO Base I inventory for input to SMOKE.

3.1.1.6 BIOGENIC SOURCES

Biogenic sources are natural sources (plants, animals, marshes, and earth itself) which emit significant quantities of pollutants. Vegetation, for example, emits large amounts of isoprene, terpenes, and other organic compounds, which are precursors of PM2.5 and ozone.

3.1.2 2009 BASE 5 ON-THE-BOOKS INVENTORY DATA SOURCES

The 2009 Base 5 on-the-books inventory accounts for countywide or statewide economic growth and local, state, and federal control measures implemented between 2002 and 2009. The major control measures are Clean Air Interstate Rule (CAIR), NOx SIP Call, Maximum Available Control Technology (MACT) standards, tier 2 rule light- and heavy-duty vehicle engine standards, low-sulfur gasoline, tier 4 rule–offroad mobile engine standards, and vehicle emission controls.

3.1.2.1 ALL POINT SOURCES EXCEPT EGUs IN MIDWEST RPO AND MINNESOTA

The growth and control factors were prepared by Alpine Geophysics by consolidating the best available growth factors from CENRAP, EPA in its latest release of the Economic Growth Analysis System (EGAS) Beta v. 5.0, VISTAS, and EPA growth factors as used in the most recent CAIR projection inventories. In addition, the latest growth and control factors from the MRPO Base K modeling were converted to SMOKE-ready format by ENVIRON and applied to the MRPO States and Minnesota.

The control factors for non-EGU point sources account for MACT standards and the NOx SIP Call for industrial boilers and cement kilns. Two modifications were made to the control packet provided by Alpine for Missouri non-EGUs. One change was the removal of the NOx SIP Call control for Missouri cement kilns because these sources are not expected to implement additional NOx controls as a result of this rule after the 2002 base year. The other revision was the removal of controls associated with the St. Louis SIP industrial surface coating rule because this rule was in place prior to 2002 and is reflected in the base year emissions inventory.

The 2002 non-EGU point source emissions were projected to 2009 by applying growth and control factors within SMOKE. The exception was for non-EGU point sources in Illinois. Because SMOKE does not properly project emissions that are in the day-specific or ptday format, growth and control factors were applied to Illinois non-EGU point source emissions outside the SMOKE system using relational database software. The 2009 emissions for the Illinois sources were then processed separately within SMOKE and merged with the other 2009 datasets. Table B-1 in Appendix B1 documents the non-EGU point source files that were grown and controlled within the SMOKE system, and Table C-6 provides detail about the non-EGU point source files processed for 2009 directly. Note that 2002 emissions for point source fires and offshore point sources located in the Gulf of Mexico were held constant for this study.

For Illinois non-EGU point sources, the provisions of recent consent decrees, preliminary NOx RACT control levels in the Metro-East counties (Madison, Monroe, and St. Clair), a proposed expansion of the Conoco-Phillips Refinery (as well as post-2002 sources not in the Base Year inventory), and the permitted Prairie State Generating Station (Washington County, Illinois) were incorporated.

The proposed Illinois NOx RACT control measures were modeled for the Illinois counties in the St. Louis nonattainment area. There are seven primary process source types and source categories targeted: industrial, commercial, and institutional (ICI) boilers; process heaters; aluminum melting; glass melting; iron and steel manufacturing; cement kilns; and lime kilns. Emission limits for combustion sources at ICI boilers and process heaters, iron and steel manufacturing facilities, and aluminum melting plants are generally represented by an emission rate expressed as a “lb/mmbtu” limit and reflect the fuel type, firing configuration, and type of control equipment. For glass melting furnaces, lime kilns, and cement kilns, the emission limit is expressed as “lb/ton” of glass, lime, or clinker produced. In certain situations, a limit may be expressed as a percentage reduction of actual emissions based upon a mode of operation (i.e. 30% reduction for combustion tuning). Sources for which a percentage reduction limit was considered applicable (e.g. catalytic cracker), were modeled conservatively by assuming the least amount of emission reduction for the range of possible percentage reductions (e.g. modeling 5% when the range is 5 – 35%). The Conoco-Phillips inventory includes a level of uncertainty in the company-supplied information as to whether certain sources will be operational in 2009. The decision by IEPA staff to include these sources in the 2009 modeling inventory is viewed as an attempt to conservatively represent the facility’s emissions.

In Missouri, all facilities that were reported as out-of business subsequent to 2002 were removed from the 2009 inventory. The permitted Holcim cement kiln in Ste. Genevieve was added to the 2009 inventory.

The Ford-Hazelwood facility was held at constant 2002 emissions levels. Based on a review of emissions reported on EIQs from 2002 through 2007, VOC emissions for this facility have decreased annually as follows: 2002 – 929.8 tons/year, 2003 – 974.3 tons/year, 2004 – 791.3

tons/year, 2005 – 309.9 tons/year, 2006 – 28.5 tons/year, and 2007 – 0 tons/year. In addition, a letter was received from Ron Brasher, Site Manager, stating that the St. Louis Assembly Plant is no longer in production mode, with no production scheduled for the foreseeable future. The department's Air Pollution Control Program believes that the trend of decreasing emissions, along with the plant's "idle mode" status are sufficient justification to hold emissions for this facility constant rather than applying growth through 2009. The letter from Ron Brasher, dated May 22, 2006, is included in Appendix C.

Comments received from Anheuser-Busch and Daimler-Chrysler based on more recent emissions data and internal growth information were incorporated. The letter sent to facilities on March 15, 2006 to solicit their input on the draft 2009 inventory, and the response letter from Anheuser-Bush, dated April 11, 2006, are included in Appendix C. The future-year emissions for Chrysler-Fenton and Chrysler-South were based on telephone conversations with Terry Tecklenberg, Daimler-Chrysler Paint Operations Specialist, in April 2006 and a review of the 2004 and 2005 EIQs for these facilities.

Emissions for JW Aluminum (510 0118, formerly Alumax) were held constant at 2002 levels. Subsequent to the 2002 base year, JW Aluminum switched to a solvent with a lower VOC content and requested to bank the resulting VOC emission reductions in accordance with Missouri's emissions banking and trading rule, 10 CSR 10-6.410, Emissions Banking and Trading. In 2002, VOC emissions for this facility were 6.1 tons/day. The total VOC emissions for this facility after the implementation of the new solvent are estimated to be 1.6 tons/day (the new permit limit of 600 tons/year divided by 365 days). The VOC emission reduction credits on a daily basis are approximately 4.5 tons/day (approved credits of 1,655 tons/year divided by 365 days), which is equal to the difference between 6.1 tons/day and 1.6 tons/day. The credits were reflected in the 2008 Ozone RFP inventory by setting the 2008 VOC emissions for this facility equal to the 2002 levels of 6.1 tons/day. See the emission reduction credit approval letter in Appendix C.

IPM model output for 2009 was used for EGU point sources. The proprietary IPM model has been used by the EPA to simulate electrical power generation and electrical power distribution scenarios based upon "least-cost" assumptions for future years and, simultaneously, generate estimates of pollutant emissions associated with these scenarios. The IPM run was conducted by ICF under contract to the RPOs. This run corresponds with the "VISTASII_PC_1f" modeling run. This run specifically addressed the emission reductions to be realized through implementation of the CAIR assuming all States participate in the EPA's trading program, Acid Rain Program (Title IV – Phases I and II), NOx SIP Call, and state and local regulations, while incorporating unit-level updates provided by power company stakeholders. Alpine Geophysics prepared the SMOKE IDA-formatted file for this IPM run. Table B-6 in Appendix B1 provides more information about the 2009 EGU emissions input file.

3.1.2.2 EGU POINT SOURCES IN MIDWEST RPO AND MINNESOTA

The MRPO provided output from the 2009 "on-the-books" RPO IPM run ("VISTASII_PC_1f") in the form of model-ready, NIF-formatted files available for direct processing with the EMS-2003 software. As with the 2002 base year inventory, unit-specific CEM-based (heat input) temporal adjustments were made to the EGU emissions that account for monthly and day-of-week variations. These adjustments replaced the use of national default temporal profiles.

3.1.2.3 AREA SOURCES

Area source emissions from 2002 were projected to 2009 by applying growth and control factors within SMOKE. The growth and control factors were prepared by Alpine by consolidating growth factors from CENRAP, EPA in its latest release of the Economic Growth Analysis System (EGAS) Beta v. 5.0, VISTAS, and EPA growth factors as used in the most recent CAIR projection inventories. The control factors reflect New Source Performance Standards (NSPS) for residential wood combustion and Stage II vapor recovery controls, including onboard vapor recovery. Table B-2 in Appendix B1 lists the area source files that were grown and controlled in the 2009 inventory. Note that 2002 emissions for offshore area sources located in the Gulf of Mexico were held constant through 2009 for this study.

3.1.2.4 OFFROAD MOBILE SOURCES

EPA's draft NONROAD2004 model was used to generate 2009 emissions for these categories. MRPO completed the runs for each month in 2009 and provided the monthly emissions data in NIF format. MDNR converted the NIF files to IDA format. Separate IDA formatted files were prepared for each month by "annualizing" the monthly emissions (dividing the monthly totals by the number of days in the month and multiplying by 365). Table B-7 in Appendix B1 documents the offroad mobile sources that were processed for 2009 directly.

For aircraft, locomotives, and commercial marine vessels, which are not included in EPA's NONROAD model, the 2002 emissions were projected to 2009 by applying growth and control factors within SMOKE. The growth and control factors were provided by Alpine Geophysics. The control factors reflect federal locomotive and commercial marine vessel engine standards. Table B-3 in Appendix B1 lists the offroad mobile emissions that were grown and controlled within the SMOKE system.

3.1.2.5 ONROAD MOBILE SOURCES

Processing of the on-road mobile inventory for 2009 was similar to 2002, in that detailed emissions were estimated using link-level inputs within SMOKE for eight St. Louis non-attainment area counties with a transportation network modeled by the East West Gateway. For the rest of the counties in each domain, county-level SMOKE inputs were used. In all cases, speed and temporal profiles remained the same for both 2002 and 2009.

The link-level VMT activity from East West Gateway for 2002 was forecast to 2009 using EPA's default growth factor of 1.7% within the St. Louis non-attainment area. The default age distributions were also used.

The following are some of the controls associated with 2009 runs:

- Tier 2 rule (light-duty vehicle engine standards and low-sulfur gasoline)
- Heavy-duty diesel engine standards and low-sulfur diesel
- Tier 4 rule (offroad mobile engine standards)
- I/M and RFG

New MOBILE6 files were used for 2009 link-based processing in SMOKE. In all five Missouri counties, 100% of vehicles were assumed to be covered by a basic I/M performance standard in 2009. A simplified minimum and maximum temperature of 74 and 97 degrees Fahrenheit, respectively, was stipulated. In Metro East counties, reformulated gasoline was newly specified in 2009. In addition, the assumption for I/M programs was that 90% of VMT was covered in Madison and St. Clair counties, and 20% of VMT in Monroe was covered. To implement these assumptions within SMOKE, the link-based VMT was split into three separate inventory (MBINV) files:

- 100% of 2009 VMT in all five Missouri counties (Missouri scenario)
- 90% of 2009 VMT from Madison & St. Clair and 20% of 2009 VMT from Monroe (Illinois I/M scenario)
- 10% of 2009 VMT from Madison & St. Clair and 80% of 2009 VMT from Monroe (Illinois no-I/M scenario)

3.1.2.6 BIOGENIC SOURCES

Biogenic emissions used for the 2009 modeling are identical to the 2002 base case modeling inventory.

3.1.3 2012 BASE 5 INVENTORY DATA SOURCES

The 2012 Base 5 on-the-books inventory and additional control measures accounts for countywide or statewide economic growth and local, state, and federal control measures implemented between 2002 and 2012. The major control measures are Clean Air Interstate Rule (CAIR) Phase I, NOx SIP Call, Maximum Available Control Technology (MACT) standards, tier 2 rule light- and heavy-duty vehicle engine standards, low-sulfur gasoline, tier 4 rule–offroad mobile engine standards, vehicle emission controls with 90% program control efficiency, Illinois' Multi-pollutant Rule-Phase I, and new Missouri SO2 and NOx RACT requirements.

3.1.3.1 ALL POINT SOURCES

The growth and control factors were prepared by ENVIRON by converting the 2012 EMS formatted files used by LADCO to SMOKE ready files. All 2009 on-the-books controls were included in the 2012 (refer to 2009 Base 5 Inventory Data Sources for details). The main differences between 2009 and 2012 are implementing 2012 growth factors, IPM 3.0 and CAIR phase 1 SO_2 control, Illinois multi-pollutant rule, Illinois RACT,,and Missouri SO_2/NO_x RACT requirements.

The 2002 non-EGU point source emissions were projected to 2012 by applying growth and control factors within SMOKE. The exception was for non-EGU point sources in Illinois. Because SMOKE does not properly project emissions that are in the day-specific or ptday format, growth and control factors were applied to Illinois non-EGU point source emissions outside the SMOKE system using relational database software. The 2012 emissions for the Illinois sources were then processed separately within SMOKE and merged with the other 2012 datasets. Table B-1 in Appendix B1 documents the non-EGU point source files that were grown

and controlled within the SMOKE system, and Table C-6 provides detail about the non-EGU point source files processed for 2012 directly. Note that 2002 emissions for point source fires and offshore point sources located in the Gulf of Mexico were held constant for this study.

IPM 3.0 model output for 2012 was used for EGU point sources. The proprietary IPM model has been used by the EPA to simulate electrical power generation and electrical power distribution scenarios based upon "least-cost" assumptions for future years and, simultaneously, generate estimates of pollutant emissions associated with these scenarios. The IPM run was conducted by ICF under contract to the RPOs. This run corresponds with the "VISTASII_PC_1f" modeling run. This run specifically addressed the emission reductions to be realized through implementation of CAIR assuming all States participate in the EPA's trading program: Acid Rain Program (Title IV – Phases I and II); NO_x SIP Call; and state & local regulations; while incorporating unit-level updates provided by power company stakeholders. The IPM 3.0 model output for 2012 was edited by IEPA and MDNR to reflect Illinois' multi-pollutant rule and Missouri's $PM_{2.5}$ emission revisions. Table B-6 in Appendix B1 provides more information about the 2012 EGU emissions input file.

Missouri has implemented several RACT findings to further limit SO_2 and NO_x emissions in the St. Louis nonattainment area. These reductions result from several different industrial sources/categories. The NOx RACT findings did not require any additional add-on control for the facilities, but will result in emission reductions from several facilities due to operational changes. In contrast, some findings only codified existing procedures and will not result in additional emission reductions. For example, MEMC uses a NO_x scrubbing system that reduces emissions from an etching process that is included, but does not represent an emission reduction for modeling purposes. The sources that have emission reductions from NO_x RACT findings are as follows:

- River Cement (1,044 tpy) resulting from a recently issued permit for a new kiln system,
- Metropolitan Sewer District located in Lemay, MO, (52 tpy) resulting from switching engines to electricity from gas. However, after running the last CMAQ simulation, the company decided due to operational issues to not implement this reduction. This reduction is very small and will not impact the overall modeling analysis. The change in operation was only considered to be RACT because the facility had agreed to the replacement. The "new" RACT finding is no additional control necessary due to cost prohibition., and
- Anheuser Busch (23 tpy) resulting from new industrial/commercial boiler regulation.

The SO_2 RACT findings also codify certain existing procedures for sources, but several sources will have sizable emission reductions from the new requirements:

New

- Anheuser Busch (3,194 tpy) resulting from new industrial/commercial boiler regulation, and
- Doe Run - Herculaneum (16,740 tpy) resulting from RACT requirement to reduce emissions from base year as part of a phased SO_2 reduction program to zero emissions in 2017 (RACT = 25,100 tpy in 2012).

Existing

- McDonnell Douglas - Boeing (128 tpy) resulting from boiler replacement of coal-fired boilers with natural gas,

- Washington University (50 tpy) resulting from boiler replacement(s) of coal-fired boiler(s) with natural gas, and
- River Cement (21 tpy) resulting from recently issued permit for a new kiln system

A complete summary of the RACT findings is provided in the RACT portion of this submittal.

3.1.3.2 AREA SOURCES

Area source emissions from 2002 were projected to 2012 by applying growth and control factors within SMOKE. The growth and control factors were prepared by ENVIRON. The control factors reflect NSPS for residential wood combustion and Stage II vapor recovery controls, including onboard vapor recovery. Table B-2 in Appendix B1 lists the area source files that were grown and controlled in the 2012 inventory. Note that 2002 emissions for offshore area sources located in the Gulf of Mexico were held constant through 2012 for this study.

3.1.3.3 OFFROAD MOBILE SOURCES

MDNR used EPA's draft NONROAD2005 model to generate 2012 emissions for these categories for all States within 36km68x68 grid. Emissions were based on running the draft NONROAD2005 with EPA's average diesel sulfur content (32 ppm) for land. Table B-7 in Appendix B1 documents the offroad mobile sources that were processed for 2012 directly.

For aircraft, locomotives, and commercial marine vessels, which are not included in EPA's NONROAD model, the 2002 emissions were projected to 2012 by applying growth and control factors within SMOKE. The growth and control factors were provided by ENVIRON. The control factors reflect federal locomotive and commercial marine vessel engine standards. Table B-3 in Appendix B1 lists the offroad mobile emissions that were grown and controlled within the SMOKE system.

3.1.3.4 ONROAD MOBILE SOURCES

Processing of the on-road mobile inventory for 2012 was similar to 2009 with the following assumptions:

- New M6 input file for MO-side St. Louis nonattainment counties (Franklin, Jefferson, St. Charles, St. Louis, St. Louis City) was created. This represents a 90% effectiveness for the new Missouri I/M program (set with the following command: I/M EFFECTIVENESS : 0.90 0.90 0.90).
- The link-based VMT for both MO- and IL-sides of the NAA (Franklin, Jefferson, St. Charles, St. Louis, St. Louis City, Madison, Monroe, St. Clair) was grown as follows: from 2002-2010 the growth rate was 1.5% per year; from 2010-2012 the growth rate was assumed to be zero (i.e., 2012 VMT = 2010 VMT).

3.1.3.5 BIOGENIC SOURCES

Biogenic emissions used for the 2012 modeling are identical to the 2002 base case modeling inventory.

3.2 EMISSIONS MODELING METHODOLOGY

Emissions inventory development for photochemical modeling must address several source categories including: stationary point sources, area sources, on-road mobile sources, non-road mobile sources, biogenic, and fire sources. For this analysis, inventories were developed for 2002, 2009, and 2012.

Development of an emissions inventory customized for the St. Louis regional modeling domains required a merging of the most recent pertinent regional inventory and available high-resolution, locale-specific emissions estimated by local, state, and regional agencies in the region. Local air regulatory and transportation planning agencies are generally the best sources of domain specific activity and control factors to use in developing the base year emissions. Often, these local emissions data sets come from a variety of sources, frequently in different formats. Section 3.1 provides further details on the inventory development.

3.3 SET-UP OF SMOKE OVER THE ST. LOUIS DOMAINS

The SMOKE modeling system is an emissions modeling system that generates hourly gridded speciated emission inputs of on-road mobile, non-road mobile, area, point, fire and biogenic emission sources for photochemical grid models. SMOKE is one of the fastest emissions processing tools currently available to the air quality modeling community. The sparse matrix approach utilized throughout SMOKE permits both rapid and flexible processing of emissions data. The processing is rapid because SMOKE utilizes a series of matrix calculations instead of less efficient algorithms used in previous systems. The processing is flexible because the processing steps of temporal projection, controls, chemical speciation, temporal allocation, and spatial allocation have been separated into independent operations wherever possible. The results from these steps are merged together at a final stage of processing.

SMOKE was configured to generate point, area, non-road, highway, and biogenic source emissions. In addition, certain subcategories, such as fires and EGUs were maintained in separate source category files in order to allow maximum flexibility in producing alternate strategies. Settings for each of the source categories are discussed in relevant previous and following sections. With the exception of biogenic and highway mobile source emissions that are generated using the, respectively, BEIS and MOBILE6 modules, respectively, in SMOKE, pre-computed annual emissions were processed using the month, day, and hour specific temporal profiles contained within the SMOKE emissions modeling system, with the exception of point sources with CEM data.

To produce an emissions inventory to support annual modeling, representative time periods were selected and modeled. Area, on-road mobile, non-road mobile and point sources were modeled as a block of four days (Friday, Saturday, Sunday and Monday) per month (total of 48 days modeled). EGU sources CEM data were processed using CEM hourly emissions representative of typical monthly emissions for weekdays and weekend days. Holidays were modeled as Sundays. A list of modeled holidays is provided in Table 3-1. The biogenic emissions were modeled on a day specific basis (365 days) using hourly meteorology from the MM5 model.

Table 3-1. SMOKE modeled holidays in 2002 (treated like Sunday emissions).

Date	Julian Day	Holiday Description
January 1, 2002	2002001	New Year's Day
March 29, 2002	2002089	Good Friday
May 27, 2002	2002147	Memorial Day
July 4, 2002	2002185	July 4th
September 2, 2002	2002245	Labor Day
November 28, 2002	2002332	Thanksgiving Thurs
November 29, 2002	2002333	Thanksgiving Fri
December 24, 2002	2002358	Christmas Eve
December 25, 2002	2002359	Christmas Day

Population was used as a gridding default for all source categories when the assigned surrogate would cause SMOKE to drop emissions. This can be a case when the county-level emission inventories are prepared using surrogates other than those available for modeling purposes.

Figure 1-1 displays the regional 36 km and 12 km domain that SMOKE was used for generating the 2002 Base Case and 2009 and 2012 future-year emission scenarios.

The parameters for the SMOKE runs are as follows:

Episodes:

2002 Calendar Base Year

Future-Years:

2009 and 2012

Output Time Zone:

Greenwich Mean Time (GTM) (zone 0)

Projection:

Lambert Conformal with Alpha=33, Beta=45, Gamma=-97, and center at (-97,40).

Domain:

36 Kilometer Grid: Origin at (-792.0, -1656.0) kilometers with 68 rows by 68 columns and 36-km square grid cells.

12 Kilometer Grid: Origin at (-264.0, -1272.0) kilometers with 128 rows by 149 columns and 12-km square grid cells.

Layer Structure:

The CMAQ and CAMx models used identical vertical layer structure with 16 layers, with specific layer positions defined in the meteorology files (see Table 1-1 in Chapter 1).

CMAQ and CAMx Model Species:

The CMAQ and CAMx configuration used the CB-IV chemical mechanism with PM. The model species in the emission input files are: CO, NO, NO2, ALD2, ETH, FORM, ISOP, NR, OLE, PAR, TERPB, TOL, XYL, NH3, SO2, SULF, PEC, PMFINE, PNO3, POA, PSO4, and PMC, with additional species for the SOA enhancements.

Meteorology Data:

Daily (25-hour). SMOKE requires the following five types of MCIP outputs: Grid cross 2-d, Grid cross 3-d, Met cross 2-d, Met cross 3-d, and Met dot 3-d. These files need to match the grid projection and overlap with the emissions modeling region but can be larger in the horizontal directions than the modeling regions shown in Figure 1-1. Therefore, the data files for the 36 and 12 km grid domains were, respectively, 68 x 68 and 128 x 149.

Elevated Sources:

Elevated sources were specified as those with a plume rise greater than or equal to 40 meters (131.2 feet) and NO_x and SO_2 emissions greater than or equal to 1.25 tons/day. No plume-in-grid sources were modeled. Where day specific and location specific wildfire data was provided by States and Federal Land Managers, wildfire emissions were handled as point sources.

Producing 365 day-specific input files for all source categories places a burden on available computing facilities and data management systems, and would have adversely affected the modeling schedule. Selecting representative model days for some or all of the source categories reduces the processing and file handling requirements to a more manageable level and in most cases does not compromise the accuracy of the emissions files.

Like other current or recent projects undertaken by EPA, CENRAP, WRAP and LADCO, the St. Louis $PM_{2.5}$ modeling has used a selection approach for all of the source categories, except biogenics, that use a representative weekday/Saturday/Sunday for each month to model all of the emissions files. Because the GMT time zone is used in the SMOKE emissions modeling, in order to obtain a representative weekday/Saturday/Sunday emissions for local time, four days in each month are actually modeled with SMOKE for Friday/Saturday/Sunday/Monday.

Biogenic emissions were modeled for each episode day, using the daily MM5 meteorology. Fire emissions were modeled for each episode day to take advantage of the available day-specific emissions and meteorology. Area sources, including non-road mobile and dust emissions do not utilize meteorological data and are temporally allocated by monthly, daily, and hourly profiles. Reviewing these profiles indicate that maximum temporal definition can be achieved by selecting representative Thursday, Friday, Saturday, Sunday, and Monday profiles for each month.

On-road mobile source emissions were also modeled for a Friday/Saturday/Sunday/Monday for each month using monthly average hourly diurnally varying meteorological conditions. Point source emissions with hourly CEM data were modeled using typical monthly diurnally emissions for a Friday/Saturday/Sunday/Monday based on the CEM data.

3.3.1 PROCESSING OF POINT SOURCE EMISSIONS

Stack parameters are often more important to the reliability of the air quality modeling results than the emissions rates themselves. Stack parameter data are frequently incorrect, especially in some of the current regional modeling inventories and careful QA is required to assure that the point source emissions are properly located both horizontally and vertically on the modeling grid. To screen for simple, but potentially serious inventory errors such as these, the study team

has modified procedures originally developed by EPA[2] to quality assure, augment, and where necessary, revise stack parameters to examine the accuracy of the point source emissions, as well as standardize procedures to identify and correct stack data errors. These procedures were implemented in the NIF to IDA conversion step of the inventory development. Additionally, SMOKE has a number of built-in QA procedures designed to catch missing or out-of-range stack parameters. These procedures were also invoked in the processing of the point source data.

Annual and daily emissions were disaggregated to hourly values using EPA default temporal profiles cross-referenced by SCC. The default temporal profiles were supplemented for Illinois and Missouri point sources with monthly profiles at the emission unit level based on seasonal throughput percentage. In addition, for EGUs in CENRAP, monthly, day of week, and hourly temporal profiles were created by Pechan under contract to CENRAP based on three-year average CEM data (2001-2003). EPA default speciation profiles were used to disaggregate the inventory species into the CB4 species (e.g., VOC into PAR, OLE, XYL, ISOP, and others). Documentation of EPA's temporal and speciation profiles and associated cross reference files is available on the Emissions Modeling Clearinghouse website.

All point sources were spatially allocated in the domain based on the stationary source geographic coordinates. If a point source was missing its latitude/longitude coordinates and data could not be found to properly site the unit within the domain, the source was placed in the center of its reported county.

3.3.2 PROCESSING OF AREA AND NON-ROAD SOURCES EMISSIONS

In order to facilitate future-year emissions processing, SCCs included in EPA's NONROAD model were separated from aircraft, locomotive, and commercial marine vessel SCCs, which are not covered by NONROAD. Because 2009 and 2012 outputs from the EPA's NONROAD model were used for future-year emissions, extracting the NONROAD model SCCs before applying growth and control factors to aircraft, locomotive, and commercial marine vessel SCCs ensured that no offroad mobile emissions were double-counted in the 2009 and 2012 inventories.

All area and non-road source emissions were temporally allocated to month, day, and hours using annual emissions and SCC based allocation factors. These factors were based on the cross-reference and profile data supplied with the SMOKE modeling system. Area and non-road sources were spatially allocated in the domain based on SCC-matched spatial allocation factor files. If an area or non-road source SCC did not have an existing cross-reference profile assigned to it, the county-level emissions were allocated by population density in the respective county.

A county-specific crustal PM transport factor was applied to fugitive dust emission sources that had been identified in EPA modeling to have only a portion of its mass transportable from the source of the emission generation. These EPA studies[3] indicate that 60 to 90 percent of PM emissions from fugitive dust sources do not reach the elevated level necessary to be transported or modeled in an episodic simulation. For this reason, the modeling team applied county-specific fugitive dust emissions transport factors to these sources to adjust PM emissions during

2 ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/point/augmentation_point/2002nei_qa_augmentation_report0206.pdf
3 http://www.epa.gov/ttn/chief/emch/invent/index.html#dust

the conversion of emission input files from the raw mass emissions. These adjusted PM emissions are reported in summary emissions tables.

3.3.3 PROCESSING OF ON-ROAD MOBILE SOURCE EMISSIONS

The MOBILE6 module of SMOKE was used to develop the base year on-road mobile source emissions estimates for CO, NH_3 NO_x, PM and VOC emissions. The MOBILE6 parameters, vehicle fleet descriptions, and VMT estimates were combined with gridded, episode-specific temperature data to calculate the gridded, temporalized emission estimates. Of note, whereas the on-network emissions estimates are spatially allocated based on link location and subsequently summed to the grid cell level, the off-network emissions estimates are spatially allocated based on a combination of the Federal Highway Administration version 2.0 highway networks and population. For the St. Louis 36/12 km modeling, no link based data was used. The MOBILE6 emissions factors are based on episode-specific temperatures predicted by the meteorological model. Further, the MOBILE6 emissions factors model accounts for the following:

- Hourly and daily minimum/maximum temperatures;
- Facility speeds;
- Locale-specific inspection/maintenance (I/M) control programs, if any;
- Adjustments for running losses;
- Splitting of evaporative and exhaust emissions into separate source categories; and
- VMT, fleet turnover, and changes in fuel composition and Reid vapor pressure (RVP).

The primary input to MOBILE6 is the MOBILE shell file. The MOBILE shell contains the various options (e.g. type of inspection and maintenance program in effect, type of oxygenated fuel program in effect, alternative vehicle mix profiles, RVP of in-use fuel, operating mode) that direct the calculation of the MOBILE6 emissions factors.
For the production of the MOBILE6 emission factors SMOKE was run using the monthly average diurnally varying hourly MM5 meteorological data for temperature and humidity. SMOKE produces emissions factors for state and county groups that are selected for regional similarities and consistent MOBILE6 option requirements (i.e. I/M programs, RVP, fuel programs). The hourly average temperature and humidity are calculated from the hourly temperatures in each grid cell in the state/county groups.
SMOKE was run using the daily average speed option for all states. The daily average speed was provided based on state, county, and roadway type.

3.3.4 PROCESSING OF BIOGENIC SOURCE EMISSIONS

Biogenic emissions were prepared for the 36-km and 12-km modeling grids using the Biogenic Emission Inventory System (BEIS) model v3.09 within SMOKE. These emissions were calculated for day of the year 2002 for each of the domains. SMOKE biogenic processing relies upon the BEIS3 emissions model, and requires domain definition, land use, and meteorological input files. Input files for land use were based on EPA's Biogenics Emissions Landuse Database version 3 (BELD3) data. Daily meteorological data, including wind speed, humidity, and temperature extracted from Met Model 5 (MM5) output were provided to SMOKE as daily MCIP files for each domain. Alpine Geophysics performed all the biogenic data processing.

A revised version of a commonly used biogenic emissions model, BEIS, was developed and tested by EPA over two separate modeling domains/episodes. This version of the model (BEIS-3, v0.9) contains several changes over BEIS-2, including the following:

- Vegetation input data -- are now based on a 1-km BELD3 vegetation data base,
- Emission factors – many updates including some recent North American Research Strategy for Tropospheric Ozone (NARSTO) modifications, and
- Environmental algorithm -- includes a sunlit/shaded leaf solar radiation model.

A series of sensitivity modeling simulations has been completed and concluded that the more recent BEIS-3 methodology will impact base case model ozone predictions in most parts of the U.S. The preliminary tests have also shown that the newer biogenic emissions do not appear to have a large effect on: the control signal response, relative reduction factors resulting from a projected emissions change, or overall regional model performance in the eastern U.S.

For this particular application of BEIS-3, v0.9, as currently incorporated in the SMOKE processor was used. This means that soil NO emissions shall be prepared without the input of specific soil moisture and precipitation data and MEOH emissions will not be modeled explicitly.

3.3.5 PROCESSING OF WILDFIRES AND PRESCRIBED BURNING EMISSIONS

Wildfire, agricultural, and prescribed burning emissions were handled separately from the standard area source input files. Day-specific or monthly estimates of fire emissions, which include burn acreage and biomass loading information, were used. Depending on the completeness and quality of the data received, specific calculations were made for spatial and temporal distributions of the fire emissions, rather than relying on standard distribution profiles. Vertical distribution of the fire emissions, based on fire size and biomass involvement, were calculated. SMOKE v2.0 can model fire plume rise when provided with the following variables:

- PTOP – Top of the fire plume profile (meters above ground level),
- PBOT – Bottom of the fire plume profile (meters above ground level), and
- Lay1 – The percent of the emissions entrained in the first modeling layer.

For those fires as having the necessary data elements to site these files with distinct time and space coordinates, these variables were prepared and included in the modeling files used to process this emission source type.

The WRAP Fire Emissions Joint Forum Emissions Inventory Report[4] has documented an approach for calculating these plume descriptors. In this method, which was used in St. Louis modeling, the fires are assigned to one of five size categories, based on the total burn acreage, and the biomass fuel loading. These categories are then used to calculate representative hourly plume profiles. These profiles are then used by SMOKE 2.0 to distribute the vertical emissions for the fires. To successfully model fires as elevated point sources, the data included both the day(s) on which the fire occurred and a spatial identifier of the fire location.

4 http://www.wrapair.org/forums/fejf/documents/WRAP_2002_PhII_EI_Report_20050722.pdf

3.3.6 WINDBLOWN DUST

PM_{10} and $PM_{2.5}$ emissions from wind erosion of natural geogenic sources (SCCs 2730100000 [total] and 2730100001 [dust devils]) were excluded from the resulting modeling files as these meteorological and episode specific categories could not be accurately reflected using the pre-calculated emission estimates and temporal profiles available at the time of the modeling.

3.3.7 SEA SALT

In March 2006 Version 4.51 of CMAQ was released that includes Sea Salt emissions and active Sea Salt chemistry. CMAQ V4.51 internally generates Sea Salt emissions using a user supplied OCEAN file. Thus, Sea Salt emissions were not addressed in the SMOKE processing. Further, Sea Salt is not a significant contributor to $PM_{2.5}$ formation in St. Louis area.

3.4 QUALITY ASSURANCE AND QUALITY CONTROL

The development of the 2002, 2009 and 2012 emissions inventories included step-by-step QA and QC. The SMOKE and EMS emissions modeling systems generate numerous summary reports that were reviewed to assure that no emissions were gained or lost in each step of the processing of the raw annual county-level emissions into gridded hourly speciated emissions needed by the photochemical models.

Tables 3-2 through 3-7 illustrate these series of QA checks for selected States based on the 2002 Base 5 typical emissions for Monday, July 15. Table 3-2 demonstrates that the raw annual point source emissions are consistent with the annual emissions after the 36 km gridding matrix has been applied. Table 3-3 shows that, for a weekday in July, the point source emissions after the application of the temporal matrix are the same as the emissions after the application of both the temporal and 36 km gridding matrices. Similar results are shown for area sources (Tables 3-4 and 3-5) and offroad mobile sources (Tables 3-6 and 3-7). However, there could be some small differences between the raw data and gridded data due to the fact that some of the grid structure of a state could lie of over other state. All “raw” emissions in these tables were taken from SMOKE output reports following the SMKINVEN step. The gridded annual emissions are from reports following the SMKINVEN and GRDMAT steps. Temporalized emissions are from reports generated after SMKINVEN and TEMPORAL, and the temporalized and gridded emissions follow SMKINVEN, GRDMAT, and TEMPORAL steps.

VOC speciation cannot be quality assured by summing the mass from SMOKE reports. The speciation step groups emissions of various compounds with different molecular weights into a single CB4 species with an average molecular weight. Once combined into the CB4 species, it is very difficult to track the mass correctly (email communications received from Marc Houyoux, EPA, and Abby Hoats and Greg Yarwood, ENVIRON, February 28, 2007). Therefore, a set of tables demonstrating mass conservancy through the speciation step is not included. As quality assurance for the SPCMAT step, as with all SMOKE processing steps, the log files were reviewed carefully and any warning or error messages were resolved.

Once the model-ready emissions files were generated for each major source category, the PAVE visualization program was used to animate the low-level emissions in order to view the spatial and temporal patterns of the emissions and identify any anomalies. Representative spatial PAVE plots are included in Appendix B3.

Table 3-2. 2002 Base 5 Typical Inventory – Comparison of Raw Annual and Gridded (36 km) Annual Point Source Emissions

State	Raw CO (tpy)	Gridded CO (tpy)	Raw NO_x (tpy)	Gridded NO_x (tpy)	Raw VOC (tpy)	Gridded VOC (tpy)	Raw NH_3 (tpy)	Gridded NH_3 (tpy)	Raw SO_2 (tpy)	Gridded SO_2 (tpy)	Raw $PM_{2.5}$ (tpy)	Gridded $PM_{2.5}$ (tpy)
Non-EGU Point Sources												
Arkansas	52517	52517	33219	33219	33272	33272	0	0	20318	20318	7660	7660
Illinois	78579	78579	93253	93253	71174	71174	494	494	136530	136530	3313	3313
Indiana	364580	364580	80432	80432	55933	55933	3090	3090	97630	97630	14073	14073
Kentucky	111570	111570	44626	44626	45042	45042	688	688	37805	37805	11516	11516
Missouri	109090	109090	41231	41231	33650	33650	2489	2489	146870	146870	7277	7277
Ohio	237970	237970	65897	65897	28622	28622	3912	3912	99489	99489	10237	10237
Tennessee	115650	115650	65627	65627	84410	84410	1613	1613	79840	79840	27851	27851
EGU Point Sources												
Arkansas	3849	3849	39200	39200	468	468	1	1	70176	70176	185	185
Illinois	14323	14323	177580	177580	1570	1570	91	91	364330	364330	4087	4087
Indiana	15475	15475	287420	287420	2016	2016	553	553	836680	836680	3865	3865
Kentucky	10975	10975	195740	195740	1274	1274	308	308	491380	491380	2703	2703
Missouri	10026	10026	140350	140350	1449	1449	15	15	242320	242320	2389	2389
Ohio	14393	14393	375500	375500	1743	1743	74	74	1001500	1001500	4448	4448
Tennessee	6399	6399	150850	150850	808	808	197	197	319910	319910	11447	11447

Table 3-3. 2002 Base 5 Typical Inventory – Comparison of Temporalized (July Weekday) and Temporalized (July Weekday) & Gridded (36 km) Point Source Emissions

State	Temporalized CO (tpd)	Temporalized & Gridded CO (tpd)	Temporalized NO_x (tpd)	Temporalized & Gridded NO_x (tpd)	Temporalized VOC (tpd)	Temporalized & Gridded VOC (tpd)	Temporalized NH_3 (tpd)	Temporalized & Gridded NH_3 (tpd)	Temporalized SO_2 (tpd)	Temporalized & Gridded SO_2 (tpd)	Temporalized $PM_{2.5}$ (tpd)	Temporalized & Gridded $PM_{2.5}$ (tpd)
Non-EGU Point Sources												
Arkansas	145	145	97	97	91	91	0	0	57	57	21	21
Illinois	322	322	356	356	313	313	1	1	380	380	9	9
Indiana	997	997	223	223	152	152	9	9	270	270	39	39
Kentucky	309	309	122	122	117	117	2	2	104	104	32	32
Missouri	303	303	113	113	95	95	6	6	403	403	21	21
Ohio	646	646	180	180	79	79	11	11	276	273	28	28
Tennessee	317	317	179	179	231	231	4	4	219	219	76	76
EGU Point Sources												
Arkansas	13	13	125	125	2	2	0	0	220	220	1	1
Illinois	102	102	713	713	9	9	0	0	1312	1312	13	13
Indiana	43	43	825	825	6	6	2	2	2494	2494	11	11
Kentucky	30	30	540	540	4	4	1	1	1358	1358	7	7
Missouri	32	32	410	410	4	4	0	0	760	760	8	8
Ohio	44	44	1134	1134	5	5	0	0	3102	3102	13	13
Tennessee	18	18	416	416	2	2	1	1	886	886	32	32

Table 3-4. 2002 Base 5 Inventory – Comparison of Raw Annual and Gridded (36 km) Annual Area Source Emissions

State	Raw CO (tpy)	Gridded CO (tpy)	Raw NO_x (tpy)	Gridded NO_x (tpy)	Raw VOC (tpy)	Gridded VOC (tpy)	Raw NH_3 (tpy)	Gridded NH_3 (tpy)	Raw SO_2 (tpy)	Gridded SO_2 (tpy)	Raw $PM_{2.5}$ (tpy)	Gridded $PM_{2.5}$ (tpy)
Arkansas	145858	145858	25392	25392	71371	71371	154353	154353	27873	27873	73673	73673
Illinois	11679	11679	22202	22202	247998	247998	102614	102614	5262	5262	25589	25589
Indiana	56738	56738	29646	29646	133231	133231	125419	125419	60938	60937	30387	30387
Kentucky	106703	106703	40608	40607	98282	98282	70446	70445	41845	41845	37719	37719
Missouri	269000	269000	34749	34749	136332	136332	175584	175584	48317	48316	109700	109700
Ohio	91600	91600	37139	37139	192330	192330	137519	137509	11252	11252	11740	11740
Tennessee	157673	157673	19841	19841	164439	164439	43230	43230	29893	29893	38658	38658

Table 3-5. 2002 Base 5 Inventory – Comparison of Temporalized (July Weekday) and Temporalized (July Weekday) and Gridded (36 km) Area Source Emissions

State	Temporalized CO (tpd)	Temporalized & Gridded CO (tpd)	Temporalized NO_x (tpd)	Temporalized & Gridded NO_x (tpd)	Temporalized VOC (tpd)	Temporalized & Gridded VOC (tpd)	Temporalized NH_3 (tpd)	Temporalized & Gridded NH_3 (tpd)	Temporalized SO_2 (tpd)	Temporalized & Gridded SO_2 (tpd)	Temporalized $PM_{2.5}$ (tpd)	Temporalized & Gridded $PM_{2.5}$ (tpd)
Arkansas	331	331	62	62	178	178	423	423	76	76	213	213
Illinois	26	26	60	60	678	678	293	293	11	11	50	50
Indiana	63	63	56	56	338	338	344	344	158	158	70	70
Kentucky	147	147	106	106	237	237	193	193	99	99	88	88
Missouri	245	245	70	70	290	290	479	479	118	118	290	290
Ohio	46	46	51	51	518	518	371	371	22	22	5	5
Tennessee	224	224	37	37	405	405	118	118	76	76	89	89

Table 3-6. 2002 Base 5 Typical Inventory – Comparison of Raw Annual and Gridded (36 km) Annual Offroad Mobile Source Emissions

State	Raw CO (tpy)	Gridded CO (tpy)	Raw NO_x (tpy)	Gridded NO_x (tpy)	Raw VOC (tpy)	Gridded VOC (tpy)	Raw NH_3 (tpy)	Gridded NH_3 (tpy)	Raw SO_2 (tpy)	Gridded SO_2 (tpy)	Raw $PM_{2.5}$ (tpy)	Gridded $PM_{2.5}$ (tpy)
Arkansas	272629	272609	62471	62471	49246	49243	49	49	5490	5490	5220	5220
Illinois	966343	966343	205465	205465	92193	92193	196	196	17834	17834	13043	13043
Indiana	533793	533793	103962	103961	53663	53663	101	101	9034	9034	6852	6852
Kentucky	289889	289869	101195	101192	34090	34090	20	20	13706	13706	5960	5960
Missouri	510585	510545	95049	95046	58390	58387	50	50	9078	9078	7166	7166
Ohio	979838	979838	149210	149210	94299	94299	150	150	14776	14776	9845	9845
Tennessee	451403	451373	95911	95903	48998	48996	32	32	10382	10382	6722	6722

Table 3-7. 2002 Base 5 Typical Inventory – Comparison of Temporalized (July Weekday) and Temporalized (July Weekday) and Gridded (36 km) Offroad Mobile Source Emissions

State	Temporalized CO (tpd)	Temporalized & Gridded CO (tpd)	Temporalized NO_x (tpd)	Temporalized & Gridded NO_x (tpd)	Temporalized VOC (tpd)	Temporalized & Gridded VOC (tpd)	Temporalized NH_3 (tpd)	Temporalized & Gridded NH_3 (tpd)	Temporalized SO_2 (tpd)	Temporalized & Gridded SO_2 (tpd)	Temporalized $PM_{2.5}$ (tpd)	Temporalized & Gridded $PM_{2.5}$ (tpd)
Arkansas	900	900	194	194	151	151	0	0	18	18	17	17
Illinois	2712	2712	569	569	255	255	1	1	49	49	36	36
Indiana	1492	1492	288	288	148	148	0	0	25	25	19	19
Kentucky	1022	1022	301	301	111	111	0	0	40	40	19	19
Missouri	1772	1772	307	307	188	188	0	0	30	30	25	25
Ohio	2741	2741	413	413	261	261	0	0	41	41	27	27
Tennessee	1565	1565	294	294	159	159	0	0	32	32	22	22

3.5 SUMMARY OF EMISSIONS

Tables 3-8 through 3-14 displays the annual NO_x, VOC, NH_3, SO_2, PM_{10}, $PM_{2.5}$ and CO emissions for counties within the St. Louis NAA by major source category (area, non-road mobile, on-road mobile, EGU point and non-EGU point) and by year (2002, 2009 and 2012). In addition, charts 3-1 through 3-5 displays the 2002 annual NO_x, VOC, NH_3, and $PM_{2.5}$ emissions for the non-attainment counties by also major source category. Generally, emissions from non-road and on-road mobile, non-EGU point and EGU point source categories are going down from the current- to future-years, whereas emissions from the area source category are going up slightly from the current- to future-years. The exceptions to this are as follows:

- VOC emissions from non-attainment area are projected to decrease from the current- to future-years.
- Ammonia emissions from area sources are projected to decrease, whereas ammonia emissions from on-road mobile, non-EGU point and EGU pints are projected to increase from the current- to future-years. The on-road mobile source ammonia increase is related to higher VMT due to on-road vehicles equipped with catalysts exhaust controls that emit ammonia. The increase in the point source ammonia emissions is related to more wide-spread use of Selective Catalytic Reduction NO_x controls and resultant ammonia slip.
- Increases in EGU point source PM_{10} and CO emissions between current- and future-years and slight increase in off-road mobile PM_{10} and CO emissions between 2002 to 2009 and then reductions to 2012.

Overall, it is expected that all pollutants will decrease from 2002 to 2012 except $PM_{2.5}$ as shown in the table and figure 3-1.

Table 3-8. Summary of a Calendar Year NOx Emissions from the 2002, 2009, & 2012 for St. Louis Nonattainment Counties

County	Area NO_x (tpy)			Offroad Mobile NO_x (tpy)			Onroad Mobile NO_x (tpy)			Non-EGU Point NO_x (tpy)			EGU Point NO_x (tpy)			Total: All Source Categories NO_x (tpy)		
	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012
Missouri																		
Franklin	706	742	764	1584	1138	845	5103	3268	2169	32	33	26	7820	10413	10534	15245	15594	14339
Jefferson	660	682	699	1781	1847	1492	6203	4090	2716	5206	6217	3726	3997	4900	4328	17846	17737	12961
St Charles	1225	1285	1317	2140	2409	1521	8325	5478	3640	465	477	232	14122	6982	2145	26277	16631	8855
St Louis	5321	5551	5670	9643	11022	7821	35406	23207	15413	928	1155	629	9489	5768	5460	60786	46703	34994
St Louis City	2102	2278	2327	4181	3777	3304	9475	6206	4131	1995	2526	1785	0	0	0	17754	14787	11547
MO NAA Subtotal	**10014**	**10538**	**10776**	**19329**	**20193**	**14984**	**64511**	**42250**	**28069**	**8626**	**10407**	**6399**	**35427**	**28063**	**22467**	**137907**	**111452**	**82696**
Illinois																		
Madison	1020	1122	1145	5560	4660	4274	8139	4787	3336	8123	3783	1698	2492	2787	1898	25333	17139	12351
Monroe	86	91	93	1978	1511	1454	1352	774	558	1	9	81	2	2	16	3419	2388	2202
Randolph*	0	0	0	0	0	0	0	0	0	29	31	129	22367	5371	6944	22396	5402	7073
St Clair	711	770	783	3827	3122	2850	8202	4820	3362	366	622	570	6	2	16	13112	9336	7581
IL NAA Subtotal	**1817**	**1983**	**2021**	**11365**	**9293**	**8578**	**17693**	**10381**	**7255**	**8519**	**4445**	**2478**	**24867**	**8163**	**8875**	**64261**	**34265**	**29207**
NAA Totals	**11831**	**12521**	**12797**	**30694**	**29486**	**23562**	**82204**	**52631**	**35325**	**17145**	**14852**	**8877**	**60295**	**36227**	**31342**	**202168**	**145717**	**111903**

*Partial Emissions from Randolph County

Table 3-9. Summary of a Calendar Year VOC Emissions from the 2002, 2009, & 2012 for St. Louis Nonattainment Counties

County	Area VOC (tpy)			Offroad Mobile VOC (tpy)			Onroad Mobile VOC (tpy)			Non-EGU Point VOC (tpy)			EGU Point VOC (tpy)			Total: All Source Categories VOC (tpy)		
	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012
Missouri																		
Franklin	2004	2023	2046	791	1158	610	2063	1358	987	562	558	766	252	315	318	5671	5412	4727
Jefferson	3703	3697	4093	1170	1589	887	2603	1755	1273	529	533	570	135	153	150	8140	7726	6973
St Charles	3664	3963	3975	2242	2514	1329	3595	2424	1757	1273	1301	1480	180	200	173	10953	10401	8714
St Louis	13781	14747	15353	8123	7145	4916	15340	10337	7483	4067	6043	4517	85	108	90	41397	38379	32359
St Louis City	5061	5246	5833	1555	1433	1000	4509	3038	2190	3808	6276	4058	0	0	0	14932	15994	13082
MO NAA Subtotal	**28212**	**29676**	**31300**	**13881**	**13839**	**8743**	**28110**	**18913**	**13690**	**10238**	**14711**	**11391**	**651**	**775**	**732**	**81093**	**77913**	**65855**
Illinois																		
Madison	6059	5895	5935	1554	1159	1101	4162	2418	1921	2685	1699	427	44	61	64	14504	11232	9448
Monroe	1713	1709	1710	217	160	166	724	487	398	23	20	18	0	0	0	2676	2376	2293
Randolph*	0	0	0	0	0	0	0	0	0	1	1	98	337	351	375	338	352	473
St Clair	4634	4442	4475	1211	843	810	4311	2496	1983	1036	1174	1510	0	0	0	11191	8955	8778
IL NAA Subtotal	**12406**	**12046**	**12120**	**2982**	**2163**	**2077**	**9196**	**5401**	**4303**	**3744**	**2894**	**2053**	**382**	**413**	**439**	**28709**	**22916**	**20992**
NAA Totals	**40618**	**41722**	**43420**	**16863**	**16001**	**10820**	**37307**	**24313**	**17993**	**13982**	**17605**	**13443**	**1033**	**1188**	**1171**	**109802**	**100829**	**86847**

*Partial Emissions from Randolph County

Table 3-10. Summary of a Calendar Year NH_3 Emissions from the 2002, 2009, & 2012 for St. Louis Non-attainment Counties

County	Area NH_3 (tpy)			Offroad Mobile NH_3 (tpy)			Onroad Mobile NH_3 (tpy)			Non-EGU Point NH_3 (tpy)			EGU Point NH_3 (tpy)			Total: All Source Categories NH_3 (tpy)		
	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012
Missouri																		
Franklin	1923	573	594	1	2	0	138	159	163	32	39	42	0	157	159	2094	930	957
Jefferson	225	84	83	1	2	0	178	206	210	109	134	144	2	77	75	514	503	514
St Charles	793	258	268	2	5	0	242	280	286	15	20	21	1	54	47	1052	617	623
St Louis	2238	627	672	6	18	1	1032	1193	1220	588	725	779	2	54	45	3865	2616	2716
St Louis City	27	30	28	2	4	2	295	342	349	8	10	11	0	0	0	333	385	390
MO NAA Subtotal	**5205**	**1572**	**1645**	**12**	**30**	**3**	**1884**	**2179**	**2229**	**752**	**928**	**998**	**4**	**342**	**326**	**7857**	**5051**	**5201**
Illinois																		
Madison	1077	359	380	4	5	2	310	300	362	23	10	8	4	33	35	1418	707	787
Monroe	850	308	219	1	1	1	54	12	63	0	0	1	0	0	0	905	321	284
Randolph*	0	0	0	0	0	0	0	0	0	0	1	1	2	113	120	3	114	120
St Clair	810	170	363	3	3	1	318	308	371	14	15	16	0	0	0	1144	497	752
IL NAA Subtotal	**2737**	**838**	**962**	**8**	**10**	**4**	**682**	**619**	**796**	**37**	**26**	**26**	**6**	**147**	**155**	**3470**	**1639**	**1943**
NAA Totals	**7943**	**2410**	**2607**	**20**	**40**	**8**	**2566**	**2799**	**3024**	**788**	**954**	**1024**	**10**	**489**	**481**	**11327**	**6691**	**7144**

*Partial Emissions from Randolph County

Table 3-11. Summary of a Calendar Year SO_2 Emissions from the 2002, 2009, & 2012 for St. Louis Nonattainment Counties

County	Area SO_2 (tpy)			Offroad Mobile SO_2 (tpy)			Onroad Mobile SO_2 (tpy)			Non-EGU Point SO_2 (tpy)			EGU Point SO_2 (tpy)			Total: All Source Categories SO_2 (tpy)		
	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012
Missouri																		
Franklin	1045	1041	1044	138	25	8	98	21	16	3	2	2	47608	65489	53594	48892	66577	54665
Jefferson	793	771	773	180	36	14	127	27	20	42647	16190	25983	23256	30291	25356	67003	47315	52147
St Charles	2071	2017	2022	213	48	16	173	37	28	687	622	629	45955	2298	8790	49100	5021	11486
St Louis	10638	10793	10828	880	386	289	739	157	119	228	221	96	16453	20554	22511	28938	32112	33843
St Louis City	4129	4514	4529	358	65	28	212	45	34	6697	12972	3567	0	0	0	11395	17596	8158
MO NAA Subtotal	**18676**	**19135**	**19197**	**1770**	**561**	**355**	**1349**	**287**	**217**	**50262**	**30007**	**30277**	**133272**	**118632**	**110251**	**205329**	**168622**	**160298**
Illinois																		
Madison	109	120	122	446	80	28	309	28	33	19075	2416	3310	7266	8309	10583	27205	10953	14076
Monroe	12	13	13	163	29	9	54	1	6	0	0	30	0	0	0	228	44	59
Randolph*	0	0	0	0	0	0	0	0	0	28	30	92	26267	27697	6944	26295	27727	7037
St Clair	75	85	86	290	53	18	317	29	34	1541	1552	1607	0	0	0	2223	1719	1746
IL NAA Subtotal	**196**	**218**	**222**	**899**	**162**	**55**	**680**	**58**	**74**	**20644**	**3997**	**5040**	**33533**	**36006**	**17527**	**55952**	**40443**	**22918**
NAA Totals	**18872**	**19354**	**19419**	**2669**	**723**	**411**	**2029**	**345**	**290**	**70906**	**34004**	**35317**	**166805**	**154638**	**127778**	**261281**	**209064**	**183215**

*Partial Emissions from Randolph County

Table 3-12. Summary of a Calendar Year PM_{10} Emissions from the 2002, 2009, & 2012 for St. Louis Nonattainment Counties

County	Area PM_{10} (tpy)			Offroad Mobile PM_{10} (tpy)			Onroad Mobile PM_{10} (tpy)			Non-EGU Point PM_{10} (tpy)			EGU Point PM_{10} (tpy)			Total: All Source Categories PM_{10} (tpy)		
	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012
Missouri																		
Franklin	11335	11326	11346	102	111	69	37	21	13	82	94	100	996	2207	1342	12552	13759	12871
Jefferson	13297	13312	13342	110	138	88	48	28	17	1113	1327	1359	513	1012	616	15080	15817	15422
St Charles	13602	13603	13614	212	271	152	65	37	23	219	258	259	156	1489	156	14254	15659	14203
St Louis	10204	10226	10257	698	864	561	276	159	96	572	634	666	318	717	316	12068	12600	11896
St Louis City	2270	2287	2296	157	155	130	79	46	28	935	1193	1230	0	0	0	3442	3680	3684
MO NAA Subtotal	**50707**	**50753**	**50855**	**1280**	**1539**	**1000**	**504**	**291**	**176**	**2921**	**3507**	**3615**	**1984**	**5425**	**2430**	**57395**	**61516**	**58076**
Illinois																		
Madison	1461	1598	1643	264	218	199	53	26	18	2161	1465	372	145	1752	508	4084	5060	2739
Monroe	532	578	593	84	65	60	9	1	3	72	91	120	0	0	0	697	736	776
Randolph*	0	0	0	0	0	0	0	0	0	14	17	84	2139	1300	1683	2152	1317	1766
St Clair	1431	1544	1582	204	163	146	54	27	18	428	509	643	0	0	0	2117	2243	2390
IL NAA Subtotal	**3424**	**3721**	**3818**	**552**	**446**	**405**	**116**	**54**	**39**	**2675**	**2082**	**1219**	**2284**	**3052**	**2191**	**9051**	**9355**	**7672**
NAA Totals	**54131**	**54474**	**54673**	**1832**	**1985**	**1405**	**620**	**345**	**214**	**5596**	**5589**	**4834**	**4267**	**8478**	**4621**	**66447**	**70872**	**65748**

*Partial Emissions from Randolph County

Table 3-13. Summary of a Calendar Year $PM_{2.5}$ Emissions from the 2002, 2009, & 2012 for St. Louis Nonattainment Counties

County	Area $PM_{2.5}$ (tpy)			Offroad Mobile $PM_{2.5}$ (tpy)			Onroad Mobile $PM_{2.5}$ (tpy)			Non-EGU Point $PM_{2.5}$ (tpy)			EGU Point $PM_{2.5}$ (tpy)			Total: All Source Categories $PM_{2.5}$ (tpy)		
	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012
Missouri																		
Franklin	2422	2416	2436	93	102	65	73	52	39	35	41	44	679	1805	915	3302	4414	3498
Jefferson	3010	3028	3058	101	127	82	94	67	50	189	231	249	350	836	420	3744	4288	3859
St Charles	2744	2752	2763	195	249	143	128	91	68	99	118	112	143	1467	143	3308	4677	3228
St Louis	2771	2813	2840	637	788	523	545	387	291	223	251	265	161	592	158	4337	4831	4078
St Louis City	714	732	740	144	143	121	156	111	83	539	658	684	0	0	0	1553	1643	1628
MO NAA Subtotal	**11661**	**11741**	**11837**	**1171**	**1409**	**934**	**996**	**707**	**531**	**1084**	**1298**	**1352**	**1333**	**4699**	**1636**	**16245**	**19854**	**16291**
Illinois																		
Madison	674	725	739	241	199	185	118	75	69	1644	15	2072	63	1595	332	2740	2610	3398
Monroe	258	276	281	77	59	56	21	3	12	1	1	4	0	0	0	356	339	352
Randolph*	0	0	0	0	0	0	0	0	0	0	0	20	1038	1096	1577	1038	1096	1596
St Clair	537	576	587	186	149	137	121	77	70	25	24	43	0	0	0	870	826	837
IL NAA Subtotal	**1469**	**1577**	**1607**	**504**	**407**	**378**	**260**	**156**	**151**	**1670**	**39**	**2139**	**1101**	**2692**	**1909**	**5005**	**4871**	**6183**
NAA Totals	**13130**	**13318**	**13444**	**1674**	**1816**	**1312**	**1257**	**862**	**682**	**2754**	**1338**	**3491**	**2434**	**7391**	**3545**	**21249**	**24725**	**22474**

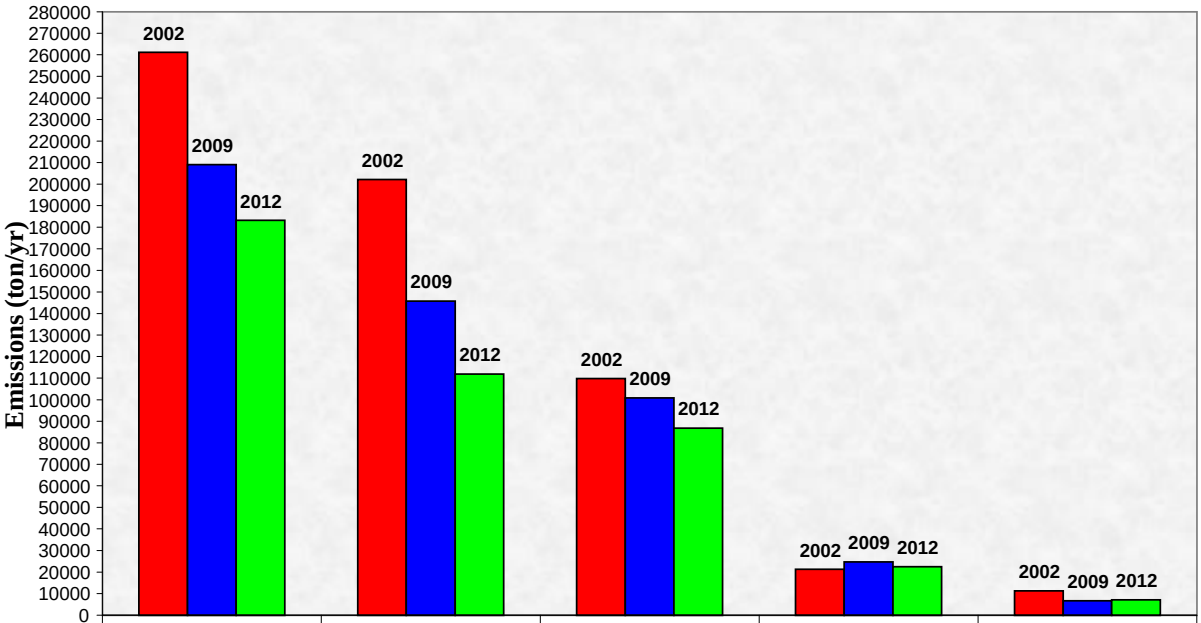
*Partial Emissions from Randolph County

Table 3-14. Summary of a Calendar Year CO Emissions from the 2002, 2009, & 2012 for St. Louis Nonattainment Counties

County	Area CO (tpy)			Offroad Mobile CO (tpy)			Onroad Mobile CO (tpy)			Non-EGU Point CO (tpy)			EGU Point CO (tpy)			Total: All Source Categories CO (tpy)		
	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012	2002	2009	2012
Missouri																		
Franklin	4820	4623	4826	6234	10472	7019	34934	23632	18722	18	18	19	2102	2623	2651	48106	41368	33236
Jefferson	7698	7733	8025	12935	23098	14961	42061	30156	23883	939	1123	3162	1126	1275	1254	64759	63384	51285
St Charles	3060	3009	3072	22910	39673	25157	56552	40407	31973	241	258	248	841	907	788	83604	84254	61237
St Louis	4123	4192	4349	121830	194260	135535	241957	173439	137348	1936	2189	2046	716	899	750	370562	374978	280027
St Louis City	1276	1320	1366	24458	35639	27728	67488	48581	38458	1290	1623	1484	0	0	0	94513	87164	69036
MO NAA Subtotal	**20977**	**20877**	**21638**	**188367**	**303142**	**210399**	**442992**	**316215**	**250383**	**4423**	**5211**	**6959**	**4785**	**5703**	**5442**	**661543**	**651148**	**494821**
Illinois																		
Madison	3120	3270	3285	19251	17971	22005	64148	33671	32492	17683	2476	13172	353	540	565	104555	57928	71520
Monroe	1074	1099	1093	2019	1897	2374	10986	1272	4988	39	45	88	0	1	0	14118	4315	8543
Randolph*	0	0	0	0	0	0	0	0	0	1	3	101	1837	1890	1998	1838	1894	2098
St Clair	1648	1714	1715	15874	14871	18584	65007	33948	32741	1179	1176	1317	1	1	0	83710	51710	54357
IL NAA Subtotal	**5843**	**6084**	**6093**	**37144**	**34738**	**42962**	**140141**	**68891**	**70221**	**18902**	**3701**	**14678**	**2191**	**2433**	**2564**	**204220**	**115846**	**136519**
NAA Totals	**26819**	**26960**	**27731**	**225510**	**337880**	**253361**	**583133**	**385106**	**320605**	**23325**	**8912**	**21637**	**6976**	**8136**	**8006**	**865763**	**766994**	**631340**

*Partial Emissions from Randolph County

Figure 3-1. St. Louis Non-Attainment Area Emissions Trends



	SO2	NOx	VOC	PM2.5	NH3
2002	261281	202168	109802	21249	11327
2009	209064	145717	100829	24725	6691
2012	183215	111903	86847	22474	7144

Chart 3-1. St. Louis Non-Attainment Area 2002 NO_x Annual Emissions

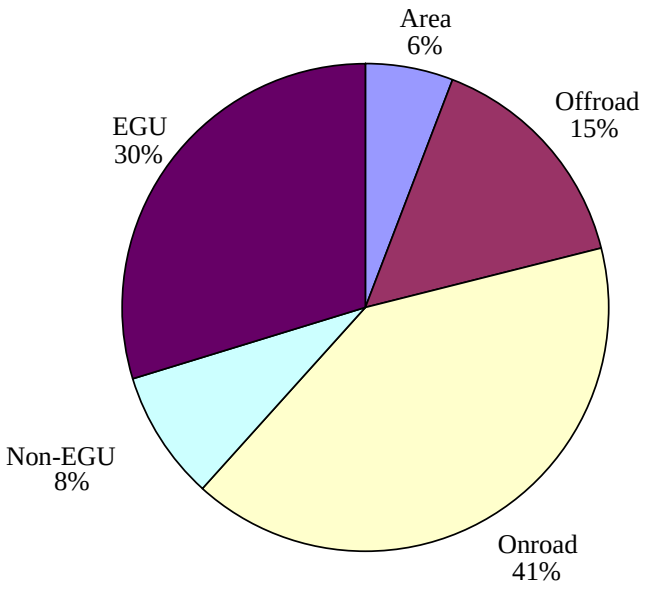


Chart 3-2. St. Louis Non-Attainment Area 2002 VOC Annual Emissions

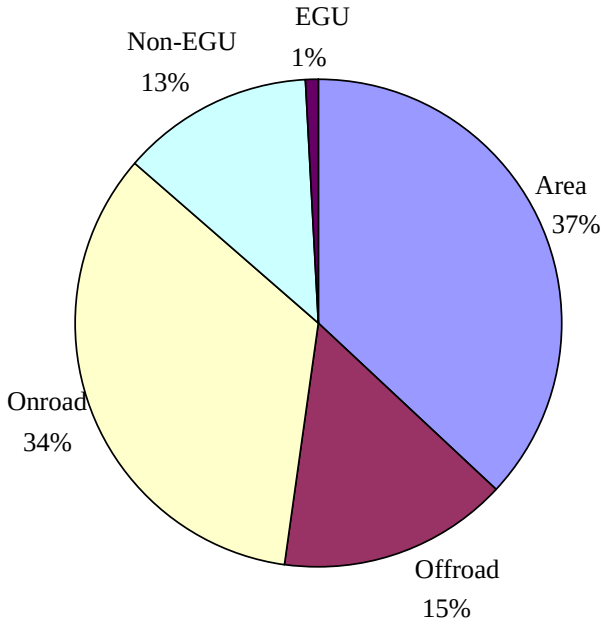


Chart 3-3. Non-Attainment Area 2002 NH_3 Annual Emissions

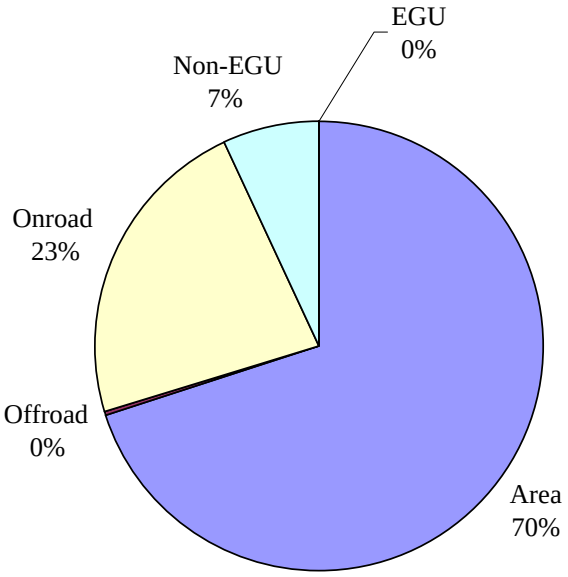


Chart 3-4. Non-Attainment Area 2002 SO_2 Annual Emissions

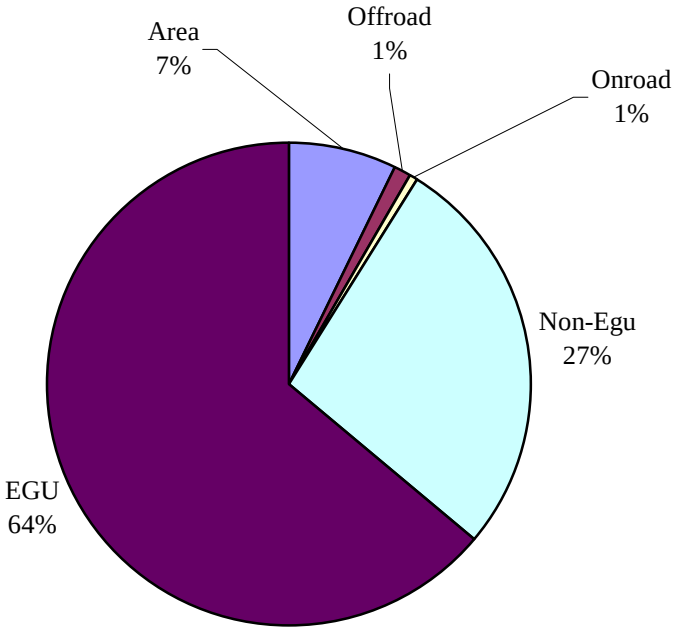
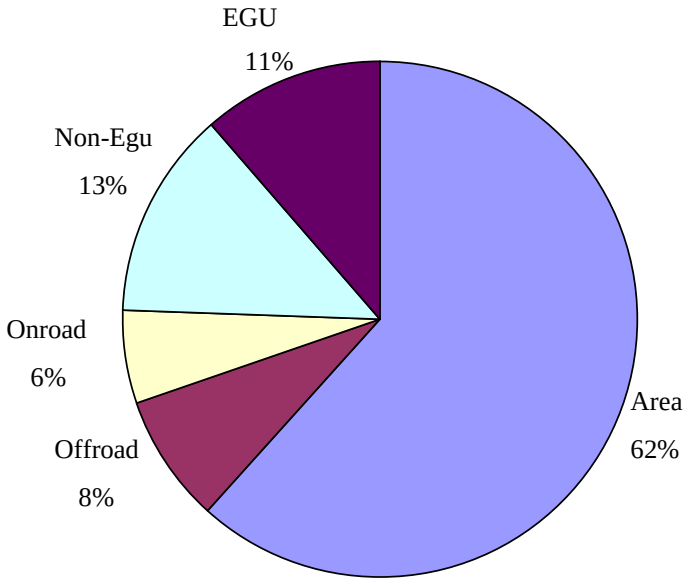



Chart 3-5. Non-Attainment Area 2002 $PM_{2.5}$ Annual Emissions