SECTION 2.0
1900 - 1939 METHODOLOGY

The SO_2, NO_x, and VOC emission estimates presented in the 1997 *Trends* report for the years 1900 through 1969, with the exception of the years 1940, 1950, and 1960,[1] were taken from two reports on historic emissions. The first contained SO_2 and NO_x emissions for the years between 1900 and 1980.[1] The VOC emissions for the years between 1900 and 1985 were contained in the second.[2] A summary of the methodologies used to estimate these emissions is presented in this document. This summary includes the basic assumptions, categorization, and calculations used to estimate these emissions. The two reports[1,2] provide a more detailed discussion of the methodologies used to estimate these emissions.

2.1 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGIES FOR SO_2 AND NO_x

A methodology for estimating historic SO_2 and NO_x emissions was developed prior to the 1940 - 1984 methodology and served as the predecessor to that methodology. These historic emissions were prepared for the years 1900 to 1980. Of these historic estimates, the 1997 *Trends* report presented the emissions for the years 1900 through 1969, except for the years 1940, 1950, and 1960.[a] The general methodologies for producing these emissions are described in this document along with specific information concerning the emissions for the years from 1900 through 1970.

The emissions were categorized based on the sources of the emissions. Each source category included specific processes which generate emissions such as the combustion of coal by railroad locomotives. The general methodology for estimating emissions was based on two factors: (1) the activity indicator which represents the activity of each process (e.g. the quantity of coal consumed by railroad locomotives) and (2) the emission factor which represents the quantity of emissions produced by the process per unit of process activity (e.g. the pounds of SO_2 produced for every ton of coal burned by a locomotive). Table 2-1 lists the source categories, along with the activity indicators and a description of the processes included in each category.

2.1.1 State-Level Estimates

The state-level SO_2 and NO_x emissions were produced for every fifth year beginning in 1900 and ending in 1970. The methodologies used to estimate the state-level emissions fall into three general groups. These groups are: (1) emissions from the combustion of fuels for heat and power, except by on-road vehicles, (2) emissions from the combustion of fuel for transportation by on-road vehicles, and (3) emissions from material processing, manufacturing, miscellaneous combustion, and miscellaneous burning. The three general methodologies used to estimate the emissions are described individually in the following sections.

[1] The emissions for the years 1940, 1950, and 1960 were estimated using the 1940-1984 methodology. This methodology is described in section 3.0 of this document.

2.1.2 Emissions from Fuel Combustion, Excluding On-road Vehicles

The source categories representing emissions produced by burning a fuel to generate heat or power are: electric utilities, industrial boilers, commercial and residential fuel uses, all uses of anthracite coal (as a fuel), all uses of wood (as a fuel), railroads, vessels, and non-road diesel engines. The emissions from each source category were further categorized by the fuel type (e.g., emissions from railroad were estimated for each of the two fuels burned by locomotives: coal and oil). The emissions from each source category and fuel type were determined using three pieces of information: (1) a fuel use indicator, (2) a fuel sulfur content (necessary to estimate SO_2 emissions only), and (3) an emission factor expressing the amount of SO_2 or NO_x produced by a given amount of fuel burned.

The primary fuel use indicator used was the state-level fuel consumption for a specific source and fuel type. If such data were unavailable, then a state-level fuel use indicator such as fuel demand, distribution, sales, or deliveries was used. Prior to 1940, state-level data were often unavailable; in these cases, a national fuel use indicator was used, if available. The national indicator was apportioned to the states using the same state/national ratios established for the earliest year having available state-level data. There were combinations of fuel types and source categories for which no fuel use indicators were available over specific time periods. For those cases listed in Table 2-2, emission estimates at the state level were not estimated.

The emission factor provided the ratio between the quantity of fuel consumed and the uncontrolled amount of SO_2 or NO_x emitted. The emission factors used to estimate the historic emissions were derived from those contained in AP-42, up to and including Supplement 14.[3] Emission factors representing a given source category, fuel type, and pollutant were weighted averages of the AP-42 emission factors representing specific processes. The weighting factors were the quantities of the specific fuel type consumed by each of the processes. These national emission factors were applied to all state-level fuel use data for all years.

In order to estimate SO_2 emissions, the sulfur content of the fuel burned was required. In 1970, the sulfur content was based on reports from individual plants. State average sulfur content was used for coal in 1965 and for other fuels in 1955. For the 1955 estimates, sulfur contents for coal were estimated for each state based on coal quality, quantity, and distribution. The emissions for all years prior to 1955 were estimated using the 1955 sulfur content data for all fuels.

The state-level emissions for SO_2 and NO_x were calculated for every fifth year between 1900 and 1970 using the general equations given below. Equations 2.1-1 and 2.1-2 were used for all fuel combustion sources.

$$SO_2\ emissions_{i,\,j,\,k} = FC_{i,\,j,\,k} \times (EF_{j,\,SO_2} \times S_{i,\,j,\,k}) \qquad \text{(Eq. 2.1-1)}$$

$$NO_X\ emissions_{i,\,j,\,k} = FC_{i,\,j,\,k} \times EF_{j,\,NO_x} \qquad \text{(Eq. 2.1-2)}$$

where: FC = fuel consumption
EF = emission factor
S = sulfur content
i = year
j = source category /fuel type
k = state

2.1.3 Emissions from Fuel Combustion by On-road Vehicles

Emissions produced by on-road vehicles were divided into two subcategories: emissions from gasoline-powered vehicles and emissions from diesel-powered vehicles. Emissions were made estimated based on three pieces of information: gasoline or diesel fuel consumption, fuel efficiency (for gasoline only), and emission factor. In 1970, vehicle miles traveled (VMT) data became available and was used in place of the state-level fuel consumption and fuel efficiency. The fuel efficiency factor was needed to correlate the amount of gasoline consumed to the average number of miles traveled. A national average miles per gallon was estimated for every fifth year between 1965 and 1935. A constant fuel efficiency was used for all years prior to 1935.

The emission factors for estimating controlled emissions from gasoline-powered vehicles were expressed in terms of the amount of SO_2 or NO_x emitted for every mile traveled. State-specific emission factors were obtained from the MOBILE2 emission factor model[4] for the years 1950 though 1970. The factors calculated for 1950 were used for all preceding years. The factors for NO_x emissions were derived to represent two distinct road types: urban and rural.

The emission factors for estimating controlled emissions from diesel-powered vehicles were expressed in term of the amount of SO_2 and NO_x emitted for every gallon of diesel fuel consumed. Unlike the emission factors for gasoline-powered vehicles, those used for diesel-powered vehicles were national and not year-specific. No fuel efficiency was required to estimate the emissions from this vehicle type.

The SO_2 and NO_x emission estimates from on-road vehicles for the years prior to 1970 were produced using Equation 2.1-3. Equation 2.1-4 was used to produce the emission estimates for 1970.

$$\textit{On-road Vehicle Emissions}_{i,j,k} = (FC_{i,k} \times FE_i) \times EF_{i,j,k} \qquad \text{(Eq. 2.1-3)}$$

$$\textit{On-road Vehicle Emissions}_{1970,j,k} = VMT_{1970,j,k} \times EF_{1970,j,k} \qquad \text{(Eq. 2.1-4)}$$

where: FC = fuel consumption
FE = fuel efficiency (gasoline-powered vehicles only)
EF = emission factor
i = year
j = SO_2 or NO_x
k = state
VMT = vehicle miles traveled (1970 estimates only)

2.1.4 Emissions from Material Processing, Manufacturing, Miscellaneous Combustion, and Miscellaneous Burning

The source categories producing emissions as the result of material processing, manufacturing, miscellaneous combustion, and miscellaneous burning were: coke plants (combustion stacks), smelters, cement plants, wildfires, miscellaneous industrial processes, and miscellaneous other processes. With the exception of the two miscellaneous categories, the emissions were generally estimated from an activity indicator and an emission factor. The activity indicator specified the industrial output of the process or, in the case of the wildfire category, the area burned. The emission factors were derived from AP-42.[3] The general equation used to calculate the emissions for both pollutants is shown in Equation 2.1-5

$$E_{i,j,k,l} = A_{i,j,k,l} \times EF_{i,j,k,l} \qquad \text{(Eq. 2.1-5)}$$

where: E = emission estimate; A = activity indicator; EF = emission factor; i = year; j = SO_2 or NO_x; k = state; l = source category

Because of the diverse nature of this group, specific details of the methodologies used to calculate the emissions will be discussed for each category individually.

2.1.4.1 Coke Plants

The methodology used to estimate the uncontrolled emissions produced from the combustion stacks of coke plants was similar that used for coal combustion. In place of the amount of coal burned, these estimates were based on the amount of coal charged into the coke ovens. The SO_2 and NO_x emissions were estimated using Equations 2.1-1 and 2.1-2, respectively, with the emission factors, the state-level coal sulfur contents, and the state-level quantities of coal charged. This methodology accounts for only about 67 percent of the total SO_2 emitted by coke plants. The remaining 33 percent of the emissions were passed to the coke oven gas and were emitted latter in the steel manufacturing process and were categorized with miscellaneous industrial processes.

2.1.4.2 Smelters

The primary smelters category consisted of copper, lead, and zinc smelters. The copper smelters predominantly emitted SO_2 and only small amounts of NO_x, while the lead and zinc smelters emitted only SO_2. The methodology used to estimate the emissions from smelters varied according to the availability of pertinent data.

For the years between 1950 and 1970, the emissions from copper smelters from all but the major producing states were estimated using the state-level amounts of copper ore concentrate produced and a national emission factor. Emissions from the major copper smelter states were obtained from a visibility study.[5] After 1960, SO_2 emissions from lead and zinc smelters were based on information obtained from a study of individual smelters.[6]

For copper smelters before 1955 and for lead and zinc smelters before 1965, a different methodology was employed. The state-level quantity of ore smelted was estimated using the amount of recoverable metal produced by the mines in a given state. It was assumed that any ore mined in a given state was smelted in the same state. If the given state was known to have no smelters, then it was assumed that the ore was smelted in the nearest state having a smelter. A national SO_2 emission factor was used to convert the quantity of recoverable metal to the uncontrolled quantity of SO_2 produced. A national NO_x emission factor was used to calculate the NO_x produced by the copper smelters.

The controlled SO_2 emissions were determined by subtracting the amount of SO_2 recovered during the production of sulfuric acid. Because only national by-product sulfuric acid production data was available, it was assumed that the amount of SO_2 recovered for each state was proportional to the smelter output for that state.

2.1.4.3 Cement Plants

SO_2 and NO_x emissions from cement plants were produced by both the minerals processed in the kiln and the combustion of fuels to heat the kiln. The industrial activity indicator used to estimates the emissions was the total annual production of portland cement by state. State-level SO_2 emission factors were the sum of the emission factors for the mineral sources, the combustion of coal, and the combustion of oil. The NO_x emission factors were average national factors. The emission factors calculated for 1955 were used to determine the emission estimates for all preceding years.

2.1.4.4 Wildfires

Wildfire emissions were defined as emissions from the combustion of vegetation in any uncontrolled fire. The activity indicator for this category was the total area burned annually in each state. This information was available for most states by 1925 and for all states by 1940. Prior to 1925, the acreage burned was assumed to be equal to the acreage burned in 1925. State-level emission factors reflected variations in vegetation (e.g. woodlands as compared to grasslands).

2.1.4.5 Miscellaneous Industrial Processes

A list of the industrial processes included in this category is given in Table 2-3. The SO_2 and NO_x emissions for this source category were determined by backcasting 1980 state-level emissions obtained from the National Emission Data System (NEDS)[7] using national growth factors. The yearly national growth factors for the years after 1940 were defined as the ratio between the national emissions for the specific year and the 1980 national emissions. Growth factors for the earlier years were based on national population. Equation 2.1-6 was used to estimate the emissions for this category.

$$SE_i = SE_{1980} \times \frac{NE_i}{NE_{1980}} \qquad \text{(Eq. 2.1-6)}$$

where: SE = SO_2 or NO_x state emission estimate
NE = SO_2 or NO_x national emission estimate
i = year

2.1.4.6 Miscellaneous Other Processes

Table 2-3 contains a list of the processes included in this category. The methodology used to estimate the emissions for this category is similar to that used above for the industrial processes. For this category, national emissions were available from the 1980 NEDS[7] and the emissions were apportioned to the states based on 1980 population data. State-level growth factors for a given year were applied to the 1980 state-level emissions to backcast the emissions for that given year. The growth factors for each state were calculated as the ratio between the estimated state population for that year and the 1980 state population. Equation 2.1-7 was used to calculate the SO_2 and NO_x emissions for this source category.

$$SE_i = SE_{1980} \times \frac{S_i}{S_{1980}} \qquad \text{(Eq. 2.1-7)}$$

where: SE = SO_2 or NO_x state emissions
S = state population
i = year

State population data for every tenth year was obtained from population census data. For the intervening years, the state populations were estimated using Equation 2.1-8.

$$S_{i+j} = (S_{i+10} - S_i) \frac{N_{i+j} - N_i}{N_{i+10} - N_i} + S_i \qquad \text{(Eq. 2.1-8)}$$

where: S = state population
N = national population
i = census year (1900, 1910, …, 1970)
j = integer 5 representing every fifth year

2.1.5 Yearly State-Level Emissions

The SO_2 and NO_x emissions were calculated every fifth year from 1900 to 1970 as described in the preceding section. For the source categories representing emissions produced by the combustion of fuels, the emissions for each intervening year were estimated by equating the changes in national fuel consumption to the changes in the state-level emissions. Consumption data for the following fuels were used: bituminous coal, anthracite coal, distillate and residual oils (combined), natural gas, wood, and gasoline and diesel fuel (combined). The interpolated state-level emissions for each pollutant were calculated using Equation 2.1-9.

$$SE_{i+j+1} = (SE_{i+5} - SE_{i+j}) \times \frac{NF_{i+j+1} - NF_{i+j}}{NF_{i+5} - NF_{i+j}} + SE_{i+j} \qquad \text{(Eq. 2.1-9)}$$

where: SE = SO_2 or NO_x state emissions by source category and fuel type
NF = national fuel consumption data corresponding to source category and fuel type
i = study year (i.e., 1900, 1905, …, 1970)
j = integer representing the intervening year (0, 1, 2, or 3)

For the following fuel types and years, the national fuel consumption changed radically and, therefore, was not used to estimate the yearly emissions: bituminous coal for the years 1912 and 1913 and natural gas for the years 1931, 1932, and 1933. In these cases, the yearly SO_2 and NO_x emissions were determined by a linear interpolation according to Equation 2.1-10.

$$SE_{i+j} = SE_i + ((SE_{i+5} - SE_i) \times j/5) \quad \text{(Eq. 2.1-10)}$$

where: SE = SO_2 or NO_x state emissions by source category
i = study year (i.e., 1900, 1905, …, 1970)
j = integer representing the intervening year (1, 2, 3, or 4)

For the source categories in which the emissions were not based on fuel consumption (i.e., smelters, cement plants, wildfire, miscellaneous industrial processes, and miscellaneous other sources), the yearly emissions were also calculated by a linear interpolation as given in Equation 2.1-10.

2.1.6 Allocation of Emission Estimates to Tier I Categories

The emission estimates for the years 1900 through 1969 (excluding 1940, 1950, and 1960) were presented graphically in the 1997 *Trends* report by Tier I categories. These categories were not the same as those used in the original calculation of the emissions as described in the preceding sections. A correspondence was developed between the original historic emission categories and the Tier I categories.

The historic emissions were summed into five general categories as shown in Table 2-4. These categories were then mapped to the Tier I categories as shown in Table 2-5. There was a one-to-one correspondence between the major historic categories and the Tier I categories for three Tier I categories: (1) Fuel Combustion - Electric Utilities, (2) Fuel Combustion - Other, and (3) On-road Vehicles. The historic emissions were assumed to be zero for two Tier I categories: (1) Solvent Utilization and (2) Storage and Transport.

The emissions from the other two historic categories were allocated to the corresponding Tier I categories based on the distribution of emissions for a specific base year. The Industrial historic category was correlated to five Tier I categories: Fuel Combustion - Industrial (02), Chemical and Allied Products Manufacturing (04), Metals Processing (05), Petroleum and Related Industries (06), and Other Industrial Processes (07). To distribute the emissions from the Industrial historic category to a specific Tier I category, a ratio between the base year emissions for the specific Tier I category and the sum of the base year emissions for all five of the Tier I categories correlated to the Industrial historic category was used. The same procedure was used to distribute the emissions from the Other historic category which

correlates to three Tier I categories: Waste Disposal and Recycling (10), Non-road Sources (12), and Miscellaneous (14). The base year was 1940, 1950, or 1960, depending on the year for which the emissions were being distributed. The emissions for these base years were developed using the 1940-1984 methodology (see section 3.0) and were distributed to the Tier I categories. The method for distributing emissions to Tier I categories is summarized in Equation 2.1-11.

$$E_{Tier1,\ i} = E_{Historic,\ i} \times \left[\frac{E_{Tier1}}{\sum (E_{Tier1\ categories\ corresponding\ to\ Historic\ category})} \right]_B \qquad \text{(Eq. 2.1-11)}$$

where: E = SO_2 or NO_x emissions
i = historic emissions year (1900, 1905, …, 1935, 1945, 1955, 1965)
B = base year: 1940 (for historic years 1900 to 1935 and 1945)
1950 (for historic year 1955)
1960 (for historic year 1965)
Historic = Industrial historic category or Other historic category
Tier I = categories 02, 04, 05, 06, or 07 or categories 10, 12, or 14
Tier I categories corresponding to Historic category
= 02 + 04 + 05 + 06 + 07 (for Industrial historic category)
10 + 12 + 14 (for Other historic category)

For the intervening years, the distribution of the emissions to the Tier I categories was made from the historic emission estimates totaled over all categories. The average percentage distribution of the total emissions to a specific Tier I category was calculated for every 6-year period (e.g., 1900 to 1905, 1925 to 1930). The percentage distribution was applied to each intervening year within the 6-year period. Equation 2.1-12 illustrates this method.

$$E_{Tier1,\ i+j} = E_{Total,\ i+j} \times \left[\frac{E_{Tier1,\ i} + E_{Tier1,\ i+5}}{E_{Total,\ i} + E_{Total,\ i+5}} \right] \qquad \text{(Eq. 2.1-12)}$$

where: E = SO_2 or NO_x emissions
i = every fifth year between 1900 and 1965
j = integer representing the intervening year (1, 2, 3, or 4)
Tier I = Tier I category
Total = totaled over all historic categories

2.2 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGY FOR VOC

The basic methodology for estimating the VOC emissions was a top-down method using national activity indicators and national emission factors. This was substantially different from the methodology used to produce the SO_2 and NO_x emission estimates where more detailed state-level data was used

wherever possible. The VOC emissions were divided into five broad source categories, each of which is subdivided into more refined subcategories. These categories and corresponding subcategories are presented in Table 2-6. For these emission estimates, the term national referred to the contiguous United States.

2.2.1 National VOC Emission Estimates (every 5 years between 1900 and 1970)

National emissions for the years 1940, 1950, 1960, 1965 and 1970 were obtained directly from the 1985 *Trends* report.[8] These data, along with that for 1975, 1980, and 1985, were used to estimates the emissions for every fifth year between 1900 and 1935 and the years 1945 and 1955. The methodology described below pertains to these years.

The two data values required to estimate the national annual VOC emissions for each source subcategory were: (1) national annual activity indicators and (2) national annual emission factors. The national activity indicators for each source subcategory for the years 1955, 1945 and every fifth year between 1900 and 1935 were obtained from a variety of sources. In cases where the activity indicators contained data from Alaska, Hawaii, or the U.S. territories, the activity indicators for areas outside the contiguous United States were subtracted from the total activity indicators. This resulted in the national (i.e., contiguous United States) activity indicator.

The development of the national annual emission factors required two steps: (1) back-calculation of the emission factors for the years 1940, 1950, and every fifth year between 1960 and 1985 and (2) extrapolation of these national emission factors to the years under study. In order to back-calculate emission factors, activity indicators and emissions were required. National emissions were obtained for the years 1940, 1950, and every fifth year between 1960 and 1985 from the 1985 *Trends* report.[8] These emissions were disaggregated into the source subcategories given in Table 2-6. The *Trends* report was also the source of the national activity indicators for all subcategories for the same years. For each year and source subcategory, a national emission factor was calculated using Equation 2.2-1.

$$NEF_{i,j} = \frac{NE_{i,j}}{NA_{i,j}} \qquad \text{(Eq. 2.2-1)}$$

where: NEF = national emission factor; NE = national emissions; NA = national activity indicator; i = year; j = source subcategory

For some source subcategories, these national emission factors were unchanged over time. In those cases, the constant emission factor was used in calculating the emissions for all years. For source categories where the national emission factors changed between the years 1940 through 1985, the emission factors for the years before 1940 and for the years 1945 and 1955 were extrapolated from the back-calculated data.

The national VOC emissions for the years 1945 and 1955, and for every fifth year between 1900 and 1935, were calculated for each subcategory using Equation 2.2-2.

$$NE_{i,j} = NEF_{i,j} \times NA_{i,j} \quad \text{(Eq. 2.2-2)}$$

where: NEF = national emission factor; i = year
NE = national emission estimate; j = source subcategory
NA = national activity indicator

2.2.2 Yearly National Emissions

The national emissions for every fifth year between 1900 and 1970 were used to interpolate the national emissions for the intervening years. The activity indicators used to the interpolate the emissions for each subcategory or group of subcategories are presented in Table 2-6. The national activity data for each year were obtained from the report of historic SO_2 and NO_x emissions.[1] The national emissions for each of the intervening years were calculated by equating the yearly change in the national activity indicators to the yearly change in the national emissions. The national emissions were calculated according to Equation 2.2-3 when using fuel consumption indicators. For source categories where population was used as the activity indicators, the yearly emissions were calculated using a linear interpolation as shown in Equation 2.2-4.

$$NE_{i+j} = (NE_{i+5} - NE_{i+j-1}) \times \frac{NA_{i+j} - NA_{i+j-1}}{NA_{i+5} - NA_{i+j-1}} + NE_{i+j-1} \quad \text{(Eq. 2.2-3)}$$

$$NE_{i+j} = NE_i + (NE_{i+5} - NE_i) \times j/5 \quad \text{(Eq. 2.2-4)}$$

where: NE = national emissions by source subcategory
NA = national activity by source category
i = study year (1900, 1905,...,1970)
j = integer representing intervening years (1, 2, 3, or 4)

2.2.3 Changes in Emissions

The emission factors for the source category External Fuel Combustion, subcategory Wood have been changed since the time the original report[2] was published. This adjustment of the erroneously high emission factors was based on more current information. The updated emission factors for the years 1900 through 1970 are presented in Table 2-7. No changes were made to the activity indicators for this subcategory. The emissions presented in the 1993 through the 1997 *Trends* reports for the years 1900 through 1969, excluding 1940, 1950, and 1960, were based on recalculated emissions for this subcategory using the adjusted emission factors. Therefore the values published in the original report differ from those presented in the most recent *Trends* reports.

2.2.4 Allocation of Emission Estimates to Tier I Categories

The emissions for the years 1900 through 1969 (excluding 1940, 1950, and 1960) were presented graphically in the 1997 *Trends* report by Tier I categories. These categories were not the same as those used in the original calculation of the emissions as described in the preceding sections. A correspondence was developed between the original historic emission categories and the Tier I categories.

The historic emissions determined by source subcategories were summed to the five major source categories described previously in Table 2-6. These categories were then mapped to the Tier I categories as shown in Table 2-8. There was only one major historic source category (Solid Waste) which corresponds directly to a Tier I category (Waste Disposal and Recycling). For all other Tier I categories, the distribution of the historic major source categories to the Tier I categories was accomplished by the same method described in section 2.1.6 for the SO_2 and NO_x emissions and summarized in Equations 2.1-11 and 2.1-12.

2.3 REFERENCES

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3. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.

4. *Mobile Source Emission Factors*. EPA-400/9-78-005 (NITS PB295672/A17). U.S. Environmental Protection Agency, Washington, DC. March 1978.

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7. *National Emissions Report, National Emissions Data System (NEDS)*. EPA-450/4-83-022 (NITS PB84-121375/MF). U.S. Environmental Protection Agency, Research Triangle Park, NC. 1984.

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Table 2-1. Historic NO_x and SO_2 Emission Source Categories, Fuel Types, and Descriptions*

Source Category	Activity Indicator Consumption or Production	Description
Electric Utilities	Bituminous Coal, Residual and Distillate Oil, Natural Gas, and Wood (after 1945)	Power plants using coal, oil or gas to provide electricity for public consumption
Industrial Boilers	Bituminous Coal, Residual and Distillate Oil, Natural Gas and Wood (after 1945)	Manufacturing and mining facilities using fuel for heat, power and chemical feedstocks, and natural gas lease and plant operations
Commercial/Residential	Bituminous Coal, Residual and Distillate Oil, Natural Gas, and Wood (after 1945)	Nonmanufacturing enterprises using fuel for heat or power and agricultural, forestry, and fisheries facilities using natural gas. Private dwellings using fuel for heating, cooking, and other household uses
Anthracite Coal - all uses	Anthracite Coal	All facilities using anthracite coal as a fuel
Wood - all uses (1900 through 1945)	Wood	All facilities using wood as a fuel
Pipelines	Natural Gas	Internal combustion engines and turbines used to compress gas
On-road Vehicles	Gasoline and Diesel fuel	Automobiles, trucks, buses, and motorcycles using gasoline or diesel fuel for transportation
Railroads	Bituminous Coal and Distillate Oil	Trains, operated railroad equipment and other related operations
Coke Plants	Bituminous Coal	Furnace and merchant plants which produce coke
Smelters	Ore	Primary copper, lead, and zinc smelting facilities
Vessels	Residual and Distillate Oil	Commercial and private boats, including ocean going vessels
Non-road Diesel Engines	Diesel Fuel	engines used in construction, logging, and road building
Cement Plants	Portland Cement	Portland cement manufacturing plants
Wildfire	Area	Projected and unprotected forest land burned
Miscellaneous	Other	Industrial processes not included about and other miscellaneous anthropogenic sources

* Taken from Reference 1, Table 1 and Table 2.

Table 2-2. Historic NO_x and SO_2 Emission Source Categories Not Estimated*

Source Categories	Range of Years
All Fuel Oil Burning	1900 to 1920
Natural Gas-fired Electric Utilities	1900 to 1915
Natural Gas-fired Industrial and Commercial/Residential Uses	1900 to 1920
Pipelines	1900 to 1945

* Taken from Reference 1, page 31.

Table 2-3. Processes Included in the Miscellaneous Source Category*

Miscellaneous Subcategory	Processes	Subprocesses
Industrial Processes	Pulp and paper	
	Petroleum Refineries	
	Iron and Steel Manufacture	
	Primary Aluminum	
	Secondary Lead	
	Glass Manufacture	
	Chemical Manufacture	sulfuric acid carbon black petrochemicals ammonia nitric acid TNT
Other Sources	Aircraft	
	Vessels	gasoline-powered coal-powered
	Miscellaneous off-highway gasoline-powered vehicles	
	Fuel combustion	LPG coke-oven gas bagasse
	Solid Waste Disposal	
	Agricultural Burning	
	Coal Refuse Burning	
	Prescribed Burning	

* Taken from Reference 1, Tables 10 and 11, page 31.

Table 2-4. Major Source Categories for SO_2 and NO_x Historic Emissions

Major Source Categories	Source Categories (used in determination of emission estimates)
Electric Utilities	Electric Utilities: bituminous coal, residual oil, distillate oil, natural gas, and wood (after 1945)
Industrial	Industrial boilers: bituminous coal, residual oil, distillate oil, natural gas, and wood (after 1945) Pipelines Coke Plants Cement Plants
Commercial/Residential	Commercial/Residential: bituminous coal, residual oil, distillate oil, natural gas, and wood (after 1945)
On-road Vehicles	On-road Vehicles: gasoline and diesel
Other	Anthracite coal (all uses) Wood (all uses from 1900 to 1940) Railroads Smelters Vessels Wildfires Non-road diesel Miscellaneous

Table 2-5. Correlation between Tier I Categories and Historic Major Source Categories for SO_2 and NO_x Emission Estimates

Tier I Categories		
Code	Name	Historic Major Source Categories
01	Fuel Combustion - Electric Utilities	Electric Utilities
02	Fuel Combustion - Industrial	Industrial
03	Fuel Combustion - Other	Commercial/Residential
04	Chemical and Allied Product Manufacturing	Industrial
05	Metals Processing	Industrial
06	Petroleum and Related Industries	Industrial
07	Other Industrial Processes	Industrial
08	Solvent Utilization	assumed zero
09	Storage and Transport	assumed zero
10	Waste disposal and Recycling	Other
11	On-road Vehicles	On-road Vehicles
12	Non-road Engines and Vehicles	Other
13	Miscellaneous	Other

Table 2-6. Source Categories and Activity Indicators for Historic VOC Emission Estimates*

Source Category	Estimates for Every Fifth Year from 1900 to 1970		Estimates for Intervening Years	
	Source Subcategory	**Activity Indicators**	**Source Subcategories**	**Activity Indicators**
TRANSPORTATION				
	On-road Vehicles	On-road Vehicle Gasoline plus Diesel Consumption	On-road Vehicles	Gasoline and Diesel Consumption
	Aircraft	Population	All Other Subcategories	Population
	Railroads			
	oil-fired	Railroad Oil Consumption		
	coal-fired	Railroad Oil Consumption		
	Vessels			
	oil-fired	Vessel Oil Consumption		
	coal-fired	Vessel Coal Consumption		
	Other Non-road Source Use	Non-road Fuel Use		
EXTERNAL FUEL COMBUSTION				
	Anthracite Coal	Anthracite Consumption	Anthracite Coal	Anthracite Consumption
	Bituminous Coal	Bituminous Consumption	Bituminous Coal	Bituminous Consumption
	Residual Oil	Residual Oil Consumption	Residual and Distillate Oil	Fuel Oil Consumption
	Distillate Oil	Distillate Oil Consumption		
	Natural Gas	Natural Gas Consumption	Natural Gas	Natural Gas Consumption
	Wood	Wood Consumption	Wood	Wood Consumption
	Coke and Other Fuels	Coke Production	Coke and Other Fuels	Population
INDUSTRIAL PROCESSES				
	Petrochemical Manufacture	Population	Petrochemical Manufacture	Population
	Petroleum Marketing		Petroleum Marketing	Gasoline and Diesel Consumption
	gasoline	On-road Vehicle Gasoline Consumption		
	other	Diesel plus Distillate Oil Consumption		

Table 2-6 (continued)

Source Category	Estimates for Every Fifth Year from 1900 to 1970		Estimates for Intervening Years	
	Source Subcategory	**Activity Indicators**	**Source Subcategories**	**Activity Indicators**
INDUSTRIAL PROCESSES (continued)				
	Surface Coating Operations	Population and Cement Production	Surface Coating Operations	Population
	Petroleum Refinery Process Operations	Crude Oil Run	All Other Subcategories	Crude Oil Consumption
	Petroleum Production			
	crude oil	Crude Oil Run		
	natural gas liquids	Crude Oil Run		
	Miscellaneous Industrial Processes	Population		
	Carbon Black Mfg.	VMT		
SOLID WASTE DISPOSAL				
	Incineration	Population	All Subcategories	Population
	Open Burning	Population		
MISCELLANEOUS OTHER SOURCES				
	Wildfire	Area Burned	All Subcategories	Population
	Prescribed Fires	State Land Area minus Wildfire Area		
	Other Burning	State Land Area minus Wildfire Area		
	Other Solvent Evaporation	Population		

* Taken from Reference 2, Tables 1 and 2, pages 5 and 9, respectively.

Table 2-7. Adjusted VOC Emission Factors for External Fuel Combustion, Wood

Year	Emission Factors (tons/1000 tons)
1900	15.28
1905	14.65
1910	14.01
1915	13.38
1920	12.74
1925	12.11
1930	11.47
1935	10.84
1940	10.21
1945	9.57
1950	8.94
1955	7.79
1960	6.65
1965	5.37
1970	4.10
1975	4.14
1980	5.24
1985	4.81
1990	5.15

Table 2-8. Correlation between Tier I Categories and Historic Major Source Categories for VOC Emission Estimates

Tier I Categories		Historic Major Source Categories
Code	**Name**	
01	Fuel Combustion - Electric Utilities	External Combustion
02	Fuel Combustion - Industrial	External Combustion
03	Fuel Combustion - Other	External Combustion
04	Chemical and Allied Product Manufacturing	Industrial Processes
05	Metals Processing	Industrial Processes
06	Petroleum and Related Industries	Industrial Processes
07	Other Industrial Processes	Industrial Processes
08	Solvent Utilization	Miscellaneous
09	Storage and Transport	Industrial Processes
10	Waste disposal and Recycling	Solid waste
11	On-road Vehicles	Transportation
12	Non-road Engines and Vehicles	Transportation
13	Miscellaneous	Miscellaneous