Development of an Interim 1990 Emission Inventory

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ABBREVIATIONS AND ACRONYMS

AADT	annual average daily traffic
AAR	American Association of Railroads
AFS	AIRS Facility Subsystem
AIRS	Aerometric Information Retrieval System
AMS	Area and Mobile Source Subsystem
APCD	air pollution control district
ASTM	American Society for Testing and Materials
BEA	Bureau of Economic Analysis
Btu	British thermal unit
CAA	Clean Air Act
CCME	Canadian Council of Ministers for the Environment
CNOI	Census Number of Inhabitants
CO	carbon monoxide
CTG	Control Techniques Guideline
DOE	Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
ERCAM-VOC	Emission Reduction and Cost Analysis Model for Volatile Organic Compounds
FAA	Federal Aviation Administration
FGD	flue gas desulfurization
FGDIS	Flue Gas Desulfurization Information System
FHWA	Federal Highway Administration
FID	Flame Ionization Detector
FIPS	Federal Information Processing Standards
FREDS	Flexible Regional Emissions Data System
FTP	Federal Test Procedure
GIS	Geographic Information System
GT	gas turbine
HDDV	heavy-duty diesel vehicle
HDGV	heavy-duty gasoline vehicle
HPMS	Highway Performance Monitoring System
IC	internal combustion
I/M	Inspection and Maintenance
LDDT	light-duty diesel truck
LDDV	light-duty diesel vehicle
LDGT	light-duty gasoline truck
LDGV	light-duty gasoline vehicle
LTO	landing-takeoff operations
MPG	miles per gallon
MPH	miles per hour
MVMA	Motor Vehicle Manufacturers Association
MW	megawatt
NADB	National Allowance Data Base
NAPAP	National Acid Precipitation Assessment Program
NEDS	National Emissions Data System
NMOG	nonmethane organic gas

ABBREVIATIONS AND ACRONYMS (continued)

NO_x	oxides of nitrogen
NRC	National Research Council
NURF	National Utility Reference File
PCE	personal consumption expenditures
RACT	Reasonably Available Control Technology
ROM	Regional Oxidant Modeling
RVP	Reid Vapor Pressure
SCC	Source Classification Code
SEDS	State Energy Data System
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SO_2	sulfur dioxide
TIUS	Truck Inventory and Use Survey
TSDF	Treatment Storage and Disposal Facility
VMT	vehicle miles traveled
VOC	volatile organic compound
WBD	wood-burning device

CHAPTER I
INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is planning to conduct regional oxidant modeling for much of the Eastern United States. To support this modeling, a comprehensive 1990 emission inventory is needed. Under the Clean Air Act (CAA), States are required to submit 1990 emission inventories, but these inventories are not scheduled for completion until November 1992. In addition, States are required to submit inventories only for their nonattainment areas, while regional modeling requires emissions for all counties. Theoretically, this 1990 point source data should be available from the AIRS Facility Subsystem (AFS), but few States have updated their point source data to reflect a base year of 1990, or are expected to do so in time to be utilized in this analysis.

This effort focused on the development of a comprehensive 1990 emissions inventory -- the 1990 Interim Inventory. Since many of the ozone episodes to be simulated occurred in years other than 1990, emission inventory data for years other than 1990 (1987, 1988, 1989, 1990, and 1991) are also needed. The pollutants covered in this inventory are volatile organic compounds (VOC), nitrogen oxides (NO_x), carbon monoxide (CO), and sulfur dioxide (SO_2).

The Interim Inventory effort was divided, by source type, into five components. These are: (1) fossil-fuel steam utilities, (2) non-utility point sources, (3) solvents, (4) other area sources, and (5) motor vehicles. Each component has separate data sources and methodologies associated with the development of its inventories. As a result, separate inventory files were provided for each component. Table I.1 lists the major data sources used to produce each of these inventories.

The fossil-fuel steam utility inventories were developed from steam, boiler-level data submitted to the U.S. Department of Energy (DOE) Energy Information Administration (EIA). These data were submitted to EIA each year by facilities with boilers of 10 MW or greater. The utility emission estimates are based, therefore, on *actual* fuel use data submitted by the utilities for four of the five inventory years. For 1991, fossil-fuel steam plant data were used.

Non-utility point source inventories were developed based on the 1985 National Acid Precipitation Assessment Program (NAPAP) Point Source Emissions Inventory (Version 2). Emissions included in the utility inventory were deleted from this file. Emissions were projected to the inventory years based on historical earnings data (by industry class) compiled by the Bureau of Economic Analysis (BEA). This assumed the same level of control technology found in the 1985 NAPAP Emissions Inventory.

Table I.1

Interim Inventories - Major Data Sources

Inventory	Data Sources	Report Chapter
Fossil-Fuel Steam Utility	Form EIA-767 (*Steam-Electric Plant Operation and Design Report*) - data available for inventory years 1987-1990 Form EIA-759 (*Monthly Power Plant Report*) - data available for 1990 and 1991	II
Non-Utility Point	1985 NAPAP Point Source Inventory BEA Historical Earnings Data	III
Motor Vehicle: VMT Emission Factors	 HPMS MOBILE4.1	IV
Solvent	Solvent Usage Estimates: Paints and Coatings: U.S. Paint Industry Data Base Other Categories: Industrial Solvent Marketing Reports BEA Earnings and Population Data	V
Area Source	1985 NAPAP Area Source Inventory BEA Historical Earnings and Population Data SEDS Fuel Consumption Data	VI

The solvent inventory was based on a material balance on total nationwide solvent consumption for 1989. National solvent usage estimates by end-use category were obtained from three main sources. For paints and coatings, the main source was a data base developed by the U.S. paint industry. Solvent usage estimates for other categories were obtained from industrial solvent marketing reports. The 1985 NAPAP methodology for solvent destruction calculations in the nationwide material balance were also used.

The area source inventory was developed based on the 1985 NAPAP Area Source Emissions Inventory. Emissions were projected to the inventory years based on historical BEA earnings data by industry, historical estimates of fuel consumption by sector and fuel type from DOE's State Energy Data System (SEDS), population, and other special category-specific indicators. Emission factor updates/changes were incorporated for railroads, residential wood combustion, and aircraft.

Stationary source VOC, NO_x, and CO emission estimates were revised to incorporate the effects of rule effectiveness. EPA-recommended 80 percent rule effectiveness was applied to all stationary source control efficiencies. Incorporating rule effectiveness increases the controlled emission estimate by discounting the reported efficiency of control devices.

The development of each of the inventories mentioned above is described more fully in the following chapters. Chapter VIII presents the quality assurance and quality control procedures followed during the development of the inventories. This chapter also provides a comparison of the 1990 emission estimates with EPA's 1990 National Emission Trends (*Trends*) estimates (EPA, 1991a) as well as a comparison between the 1985 National Utility Reference File (NURF) and the National Allowance Data Base (NADB).

Table I.2 shows the national emission estimates by source type for 1987 through 1991. These emissions are for the 48 contiguous States. Appendix A presents State-level emission summaries by source type.

Non-utility point source emission totals for the Interim Inventory are significantly different from 1985 NAPAP Inventory values for VOC and CO because an 80 percent rule effectiveness factor was applied in computing stationary source emissions for the Interim Inventory. Discounting for rule effectiveness produces the largest emission differences at emission sources where the efficiencies of existing controls are high. Despite efforts taken during this study to correct control efficiencies for Texas sources that were obviously in error, other high control efficiencies in the 1985 NAPAP Inventory point source file appear to have caused some large increases when rule effectiveness was applied at the source level. As an example, one petroleum refinery catalytic cracking unit, whose CO emissions are controlled by a CO boiler, with a listed control efficiency of 99.9 percent, has CO emissions of 5,000 tons per year before rule effectiveness is applied. After a rule effectiveness factor is applied, estimated CO emissions from this source are one million tons per year. Because EPA's AP-42 says that CO waste heat boilers reduce CO emissions from FCC units to negligible levels, it seems unlikely that the rule effectiveness policy can be accurately simulated in all cases through an across-the-board 80 percent factor.

Table I.2

Interim Inventory - National Emission Summary
(thousand tons per year)

Pollutant/Category	1985 NAPAP	1987	1988	1989	1990	1991
VOC						
Utility*	39	30	32	32	32	31
Non-Utility Point	2,120	5,338	5,603	5,542	5,557	5,567
Solvent	4,630	4,650	4,815	4,839	4,864	4,896
Area Source	8,002	6,898	6,990	6,915	6,878	6,789
Motor Vehicle	7,363	6,753	6,478	5,342	5,075	4,753
TOTAL VOC	22,154	23,669	23,918	22,670	22,406	22,036
NO_x						
Utility*	6,614	7,073	7,472	7,551	7,467	7,394
Non-Utility Point	2,853	2,611	2,684	2,654	2,670	2,652
Solvent	0	0	0	0	0	0
Area Source	4,249	4,623	4,786	4,896	4,933	4,966
Motor Vehicle	6,810	7,043	6,891	6,504	6,411	6,017
TOTAL NO_x	20,526	21,350	21,833	21,605	21,481	21,029
CO						
Utility*	310	289	301	307	302	300
Non-Utility Point	5,151	8,205	8,438	8,429	8,417	8,278
Solvent	0	0	0	0	0	0
Area Source	20,485	19,466	19,245	18,745	18,268	17,882
Motor Vehicle	34,987	53,716	51,404	45,714	43,719	40,562
TOTAL CO	60,933	81,676	79,388	73,195	70,706	67,022
SO_2						
Utility*	16,025	15,661	15,936	16,173	15,824	15,565
Non-Utility Point	5,156	4,931	5,089	4,990	4,926	4,860
Solvent	0	0	0	0	0	0
Area Source	1,446	1,447	1,446	1,418	1,408	1,480
Motor Vehicle	511	540	569	580	611	634
TOTAL SO_2	23,138	22,579	23,040	23,161	22,769	22,539

NOTES: * Utility = Fossil-Fuel Steam Utilities.

Differences between 1985 NAPAP motor vehicle emitted CO emissions and those for 1987 through 1991 occur because the MOBILE4.1 emission factors used in the Interim Inventory differ from those of the motor vehicle emission factor model used to construct the NAPAP Inventory, and the assignment of speeds to roadway types is different in the two inventories. While these differences also exist for NO_x and VOC, the resulting emissions difference is greater for CO because the MOBILE4.1 CO speed correction factors are more severe than those for the other pollutants.

CHAPTER II
ELECTRIC UTILITY EMISSIONS

The electric utility industry in the United States accounted for 67 percent of SO_2 and 30 percent of NO_x emissions in 1980. The U.S. Congress has responded to increased public concern about the environment by passing amendments to the CAA in 1990. Title IV, the Acid Deposition title of the CAA, requires emissions reductions to be achieved in stages. As a result of Title IV, electric utilities will be expected (by 2010) to achieve 87 percent of the 10-million-ton reduction required by Title IV for SO_2 (8.7 million tons) and to achieve 100 percent (2 million tons) of the NO_x emission reduction required by Title IV.

As suggested by a recommendation from the National Research Council (NRC) (NRC, 1991), NO_x control will probably be necessary either to complement or substitute for VOC control to substantially reduce ozone concentrations in many urban, suburban, and rural areas of the United States; this will likely increase the focus on the contribution of utilities to the country's ozone nonattainment problems.

With the potential contribution of utilities to both nonattainment and acid deposition problems, it is crucial to use the most specific and detailed information available in developing the steam electric utility portion of the emission inventories used for 1987 through 1991.

A. 1987-1990 STEAM ELECTRIC UTILITY EMISSION INVENTORIES

As mentioned in Chapter I, EIA collects monthly, boiler-level data on a yearly basis from Form EIA-767 (*Steam-Electric Plant Operation and Design Report*) (DOE, 1987-1990). EIA also collects fossil-fuel, plant-level data from all electric utility plants from Form EIA-759 (*Monthly Power Plant Report*) (DOE, 1992). Currently, EIA-767 data are available through 1990, while EIA-759 data are available through 1991. The steam portion of the emission inventories for 1987 through 1991 employs data from these two forms. These steam inventories *only* include boiler-level data -- not data for gas turbines (GT) or internal combustion (IC) engines. (The latter account for a very small share of electric utility fuel use and corresponding emissions and are included in the non-utility point source inventory.)

The *steam* emissions inventory data for 1987 through 1990 are based on the aggregated monthly electric utility steam boiler-level data from Form EIA-767. All plants of at least 10 megawatt (MW) which have at least one operating boiler are required to provide this information to EIA, although the amount of data required from plants with less than 100 MW of steam-electric generating capacity is much less. For plants with a nameplate rating from 10 MW to less than 100 MW, only selected pages of the Form EIA-767 must be completed. Stack and flue information is not required for these smaller plants.

1. *Processing Computerized Raw Data*

The basis for the fossil-fuel-fired steam electric utility component of the Interim Inventory is the reported primary utility data collected by EIA. The data from these EIA forms are transferred to data tapes that are not initially serviceable to the public. Pechan has developed customized computer code to process these data and to account for the various characteristics of the data tapes.

a. *Form EIA-767*

Form EIA-767 data are reported by the operating utility for each plant with fossil-fuel steam boilers of 10 MW or greater. The written form is designed so that information for each plant is reported on separate pages that relate to different levels of data. The relevant data levels are as follows:

- Plant-level: One page for delineating the plant configuration which establishes the number of and IDs for each boiler, as well as the associated generator(s), flue gas desulfurization (FGD) unit(s), flue(s) and stack(s). These do not necessarily have a one-to-one correspondence.

- Boiler-level: One page per boiler for monthly fuel consumption and quality data (for coal, oil, gas, and other), one page for regulatory data, and one page for design parameters.

- Generator-level: One page for data relating to up to five generators.

- FGD-level: One page for up to five FGD units for annual operating data and one page for each FGD unit for design parameter data.

- Flue- and stack-level: One page per flue-stack for design parameter data.

Processing Form EIA-767 is accomplished in a series of steps aimed at converting the computerized data into data base form. Each "page" format is reproduced on the computer file exactly as it appears on the written page of the form. The data from each "page" must be extracted from the computer file, associated with the correct boiler, and combined with all corresponding data from the other pages for that boiler.

For example, fuel-related boiler data -- monthly values for each fuel burned, along with its associated sulfur, ash, and heat content -- are reported on page six. These data must be aggregated for each fuel in order to produce annual estimates for each boiler before they are combined with the other data (such as control devices and efficiencies, plant location data, associated generator generation, and associated stack parameters).

After Source Classification Codes (SCCs) are assigned to each reported fuel for each boiler within a plant, the SCC-specific data are then separated so that each Interim Steam Inventory data base observation is on the plant-boiler-SCC level.

b. Form EIA-759

Form EIA-759 data are also processed in a series of steps, using a less intricate method, since the data for each plant are not reported at the boiler level, but instead are reported by prime mover (steam, hydro, IC, GT, combined cycle, for example) and fuel type.

For each plant-prime mover combination (in this case, for the steam prime mover), plant ID data, as well as monthly fuel-specific generation and consumption data, are reported. The plant steam prime mover monthly data are aggregated to annual estimates for each fuel (that has been categorized as coal, residual oil, distillate oil, natural gas, or other) and combined to produce a single steam plant-level annual data observation.

These data were utilized to "grow" the 1990 fuel and emissions data for 1991, as described later in this Chapter.

2. Emissions Algorithms

Data that were not obtained directly from the computerized data files (or converted to other measurement units) were developed by Pechan using algorithms that have been utilized since the 1980s. These variables include heat input, pollutant emissions, NO_x control efficiencies, and SCC. AP-42 (or Federal) emission factors (EPA, 1991b) were used in calculating emissions and were obtained from EPA's OAQPS CHIEF Bulletin Board. The emission factor used depends upon the SCC and pollutant.

- The appropriate SCC is assigned to each fuel based on its characteristics. For coal, the SCC is based on the American Society for Testing and Materials (ASTM) criteria for moisture, mineral-free matter basis (if greater than 11,500 Btu/lb, coal type is designated to be bituminous; if between 8,300 and 11,500 Btu/lb, coal type is designated to be subbituminous; and if less than 8,300 Btu/lb, coal type is designated to be lignite) and the boiler type as categorized by AP-42 (EPA, 1991b). If both coal and oil were burned in the same boiler, it is assumed that the oil is distillate; otherwise, it is assumed to be residual. Then, based on the fuel and boiler type, the SCC is assigned. For natural gas, the SCC is based on fuel and boiler type. See Table II.1 for a complete list of the relationships among fuel type, firing type, bottom type, and SCC.

- NO_x control efficiency is based on the assumption that the unit would be controlled so that its emission rate would equal its limit, expressed on an annual equivalent basis. After calculating the heat input, the controlled emissions achieving compliance with the applicable standard is back-calculated. After calculating the uncontrolled NO_x emissions, the presumed net control efficiency is calculated.

Table II.1

Steam Electric Utility Unit
Source Classification Code Relationships

Fossil-Fuel	Firing Type	Bottom Type	SCC
Coal			
Bituminous	No data	No data	10100202
		Wet	10100201
		Dry	10100202
	Wall	No data	10100202
		Wet	10100201
		Dry	10100202
	Opposed	No data	10100202
		Wet	10100201
		Dry	10100202
	Tangential	No data	10100212
		Wet	10100201
		Dry	10100212
	Stoker	All	10100204
	Cyclone	All	10100203
Subbituminous	No data	No data	10100222
		Wet	10100221
		Dry	10100222
	Wall	No data	10100222
		Wet	10100221
		Dry	10100222
	Opposed	No data	10100222
		Wet	10100221
		Dry	10100222
	Tangential	No data	10100226
		Wet	10100221
		Dry	10100226
	Stoker	All	10100224
	Cyclone	All	10100223

Table II.1 (continued)

Fossil-Fuel	Firing Type	Bottom Type	SCC
Coal			
Lignite	No data	All	10100301
	Wall	All	10100301
	Opposed	All	10100301
	Tangential	All	10100302
	Stoker	All	10100306
	Cyclone	All	10100303
Residual oil	No data	All	10100401
	Wall	All	10100401
	Opposed	All	10100401
	Tangential	All	10100404
	Stoker	All	10100401
	Cyclone	All	10100401
Distillate oil	No data	All	10100501
	Wall	All	10100501
	Opposed	All	10100501
	Tangential	All	10100501
	Stoker	All	10100501
	Cyclone	All	10100501
Natural gas	No data	All	10100601
	Wall	All	10100601
	Opposed	All	10100601
	Tangential	All	10100604
	Stoker	All	10100601
	Cyclone	All	10100601

- The following equation is used to compute controlled NO_x emissions (with EPA-specified 80 percent rule effectiveness):

$$\underset{(tons)}{NO_x} = \underset{burned}{fuel} * \underset{emf}{AP\text{-}42} * (1 - (.8 * eff/100)) * (1/2000) \tag{1}$$

- The following equation is used to compute controlled SO_2 emissions:

$$\underset{(ton)}{SO_2} = \underset{burned}{fuel} * \underset{emf}{AP\text{-}42} * \%sulfur * (1 - eff/100) * (1/2000) \tag{2}$$

- The following equation is used to compute uncontrolled VOC and CO emissions (there were no control efficiencies):

$$\underset{(tons)}{VOC\ and\ CO} = \underset{burned}{fuel} * \underset{emf}{AP\text{-}42} * (1/2000) \tag{3}$$

- The following equation is used to compute heat input:

$$\underset{(MMBtu)}{heat\ input} = \underset{burned}{fuel} * \underset{content}{heat} \tag{4}$$

Although Form EIA-767 data are collected from plants with a total plant capacity of at least 10 MW, there are fewer required data elements (identification data, boiler fuel quantity and quality data, and FGD data if applicable) for those plants with a total capacity between 10 MW and 100 MW. Thus, missing values are introduced in these situations. Because of time constraints, most data elements are not assigned a default value other than zero. If variables for boiler firing and bottom type were missing (these are needed in the SCC assignment) the default values for wall-fired and dry bottom type are assigned. If the longitude and latitude for a specific boiler were missing, they were replaced whenever possible with either (1) the latitude and longitude from other boilers in that same plant, or (2) county centroid coordinates.

B. 1991 STEAM EMISSION INVENTORY

The 1991 monthly computerized fossil-fuel plant-level data from EIA-759 are used in conjunction with 1990 EIA-767 data to develop the 1991 steam emission inventory file, since the 1991 EIA-767 data are not available. The data for the 1991 steam emission inventory are the same as those for the 1990 inventory except that the fuel quantity and emissions variables are "grown" by a factor based on the ratio of the 1991 Form EIA-759 plant-level, fuel-specific data to the data for 1990.

Note that no new plants are added or subtracted from the 1990 steam inventory to produce the 1991 steam inventory, so that the six new plants with data in the 1991 EIA-759 file are not included in the 1991 inventory records and their fuel data are not included in the growth ratios. However, additional boilers were added or retired from the 1990 inventory that were considered for the plant-level, 1991 EIA-759 data. Although these boilers would not be physically included in or excluded from the records in the 1991 steam inventory, their fuel data would be incorporated in the growth ratios and would be reflected in the 1991 data for the other boilers in the plant. As a result, the 1991 figures should be considered to be *preliminary* estimates only.

C. EMISSION SUMMARIES

Steam electric utility emission summaries are provided in Tables II.2 through II.6. Table II.2 is a summary of VOC, NO_x, CO, and SO_2 emissions by fuel type for each inventory year. As can be seen from Table II.2, overall emissions increased for all four pollutants in 1988 and 1989, while in 1990 and 1991, overall emissions declined.

- For bituminous coal, the largest emissions contributor, this same pattern holds for all pollutants.
- For subbituminous coal, the pattern is not the same for VOC, NO_x, or CO (which decreased in 1989 and increased in 1988, 1990, and 1991) or SO_2 (which decreased only in 1990).
- For lignite coal, all pollutant emissions increased each year following 1987.
- For residual oil, VOC and CO followed the overall pattern while NO_x and SO_2 decreased only in 1990.
- For distillate oil, VOC decreased in 1991; NO_x and CO increased only in 1989; and SO_2 followed the overall pattern of decreasing in 1990 and 1991.
- For natural gas, the emissions of all four pollutants stayed relatively constant over the study period.

Table II.3 is a summary of 1990 NO_x emissions by State and fuel type. Table II.4 shows the same information for SO_2. Table II.5 lists the top 50 NO_x-emitting steam electric utility plants for 1990. Table II.6 lists the top 50 SO_2 facilities for the same year.

Ohio and Indiana are the two States that emit the most SO_2. Pennsylvania is the third greatest SO_2 emitter. These three States account for almost one-third of the SO_2 emissions from fossil-fuel steam boilers (see Table II.3). Ohio and Indiana are also the top two coal NO_x emitters. When natural gas NO_x emissions are included, Texas becomes the top State NO_x emitter. These three States account for almost one-fourth of the NO_x emissions from fossil-fuel steam boilers (see Table II.4).

The top utility emitters can be determined from Table II.5 and Table II.6. Nine plants, of which three are in Ohio and three are in Indiana, are among the top 20 plant emitters of both NO_x and SO_2. Two Indiana plants -- Gibson and Clifty Creek -- are among the top six emitters of both pollutants.

Table II.2

Summary of Steam Electric Utility Emissions

Pollutant	1987	1988	1989	1990	1991
	Emissions (thousand tons)				
VOC					
Total	30	32	32	32	31
Bituminous Coal	16	16	17	16	16
Subbituminous Coal	7	8	8	8	8
Lignite Coal	2	3	3	3	3
Residual Oil	3	3	4	3	3
Distillate Oil	0	0	0	0	0
Natural Gas	2	2	2	2	2
NO_x					
Total	7,073	7,472	7,551	7,467	7,394
Bituminous Coal	4,538	4,630	4,675	4,610	4,500
Subbituminous Coal	1,410	1,659	1,650	1,705	1,738
Lignite Coal	336	385	390	398	402
Residual Oil	186	243	254	192	194
Distillate Oil	4	4	4	3	3
Natural Gas	599	551	578	559	557
CO					
Total	289	301	307	302	300
Bituminous Coal	138	140	143	141	138
Subbituminous Coal	57	66	65	68	70
Lignite Coal	21	23	23	24	24
Residual Oil	18	23	24	18	18
Distillate Oil	1	1	1	1	1
Natural Gas	53	48	51	51	50
SO_2					
Total	15,661	15,936	16,173	15,824	15,565
Bituminous Coal	13,513	13,547	13,588	13,352	13,061
Subbituminous Coal	1,182	1,311	1,423	1,421	1,441
Lignite Coal	338	368	409	438	445
Residual Oil	616	697	739	603	612
Distillate Oil	11	12	14	10	5
Natural Gas	1	1	1	1	1

Table II.3

1990 Steam Electric Utility NO_x Emissions by State and Fuel Type

State	NO_x Emissions (thousand tons) Coal-Fired	Oil-Fired	Gas-Fired	Total
AL	194.0	0.1	0.7	194.8
AR	75.9	0.1	6.4	82.4
AZ	117.4	0.1	2.7	120.2
CA	0.0	8.8	101.8	110.6
CO	127.6	0.0	1.4	129.0
CT	8.7	14.4	0.7	23.8
DC	0.0	0.7	0.0	0.7
DE	18.9	2.8	2.4	24.1
FL	238.4	47.9	36.5	322.8
GA	229.4	0.2	0.3	229.9
IA	120.7	0.0	0.7	121.4
IL	338.7	1.9	1.5	342.1
IN	506.0	0.2	1.4	507.6
KS	116.4	0.0	4.0	120.4
KY	330.6	0.1	0.0	330.7
LA	78.4	0.2	52.7	131.3
MA	42.2	27.2	10.2	79.6
MD	85.2	7.7	3.0	95.9
ME	0.0	3.7	0.0	3.7
MI	289.3	1.6	2.1	293.0
MN	154.3	0.0	1.2	155.5
MO	268.2	0.1	0.7	269.0
MS	35.8	1.7	13.2	50.7
MT	60.3	0.0	0.0	60.3
NC	161.4	0.1	0.0	161.5
ND	115.1	0.0	0.0	115.1
NE	77.6	0.0	0.6	78.2
NH	20.4	3.4	0.0	23.8
NJ	41.4	5.5	8.4	55.3
NM	111.7	0.0	3.8	115.5
NV	56.7	0.6	5.8	63.1
NY	89.0	57.4	39.5	185.9
OH	522.6	0.3	0.1	523.0
OK	102.7	0.1	36.5	139.3
OR	5.7	0.0	0.0	5.7
PA	369.7	5.4	0.2	375.3
RI	0.0	0.5	1.5	2.0
SC	81.0	0.1	0.9	82.0
SD	20.4	0.0	0.0	20.4
TN	192.1	0.1	0.0	192.2
TX	477.2	0.8	217.4	695.4
UT	99.8	0.0	0.0	99.8
VA	69.4	1.3	0.1	70.8
VT	0.0	0.0	0.2	0.2
WA	36.7	0.0	0.0	36.7
WI	156.7	0.0	0.5	157.2
WV	306.9	0.2	0.0	307.1
WY	161.9	0.0	0.0	161.9
Total	6,712.5	195.5	559.4	7,467.4

Table II.4

1990 Steam Electric Utility SO_2 Emissions By State and Fuel Type

State	SO_2 Emissions (thousand tons) Coal-Fired	Oil-Fired	Gas-Fired	Total
AL	528.5	0.1	0.0	528.6
AR	69.0	0.1	0.0	69.1
AZ	120.3	0.1	0.0	120.4
CA	0.0	7.7	0.1	7.8
CO	87.6	0.0	0.0	87.6
CT	10.6	42.5	0.0	53.1
DC	0.0	2.5	0.0	2.5
DE	38.9	8.1	0.0	47.0
FL	484.2	161.7	0.0	645.9
GA	874.7	0.8	0.0	875.5
IA	180.5	0.1	0.0	180.6
IL	895.5	3.7	0.0	899.2
IN	1,510.7	0.3	0.0	1,511.0
KS	87.6	0.1	0.0	87.7
KY	915.2	0.2	0.0	915.4
LA	98.2	0.4	0.1	98.7
MA	102.3	130.0	0.0	232.3
MD	256.7	25.8	0.0	282.5
ME	0.0	11.5	0.0	11.5
MI	372.3	3.4	0.0	375.7
MN	84.4	0.0	0.0	84.4
MO	783.8	0.4	0.0	784.2
MS	107.7	11.4	0.0	119.1
MT	17.9	0.0	0.0	17.9
NC	336.3	0.2	0.0	336.5
ND	126.5	0.0	0.0	126.5
NE	50.6	0.0	0.0	50.6
NH	43.1	25.4	0.0	68.5
NJ	70.9	6.2	0.0	77.1
NM	64.0	0.1	0.0	64.1
NV	54.5	1.2	0.0	55.7
NY	269.9	146.8	0.1	416.8
OH	2,240.2	0.9	0.0	2,241.1
OK	101.6	0.2	0.0	101.8
OR	4.9	0.0	0.0	4.9
PA	1,200.7	12.7	0.0	1,213.4
RI	0.0	1.1	0.0	1.1
SC	167.2	0.2	0.0	167.4
SD	31.2	0.0	0.0	31.2
TN	796.4	0.1	0.0	796.5
TX	466.7	1.2	0.3	468.2
UT	32.0	0.0	0.0	32.0
VA	154.2	4.4	0.0	158.6
VT	0.0	0.0	0.0	0.0
WA	58.7	0.0	0.0	58.7
WI	284.8	0.1	0.0	284.9
WV	945.0	0.3	0.0	945.3
WY	84.6	0.0	0.0	84.6
Total	15,210.7	612.3	0.8	15,823.7

Table II.5

1990 Interim Inventory
Top 50 Steam Utility NO_x Emitters

Rank	State	County	Plant ID	Plant Name	Latitude	Longitude	Emissions (tpy)
1	KY	MUHLENBURG	1378	PARADISE	037 15 39	086 58 42	97,829
2	TX	RUSK	6146	MARTIN LAKE	032 15 38	094 34 15	89,677
3	MI	MONROE	1733	MONROE	041 53 28	083 20 40	85,442
4	IN	GIBSON	6113	GIBSON	038 21 32	087 46 42	74,632
5	NM	SAN JUAN	2442	FOUR CORNERS	036 41 26	108 28 56	72,280
6	IN	JEFFERSON	983	CLIFTY CREEK	038 44 20	085 25 09	70,692
7	OH	ADAMS	2850	J M STUART	038 38 14	083 41 44	68,629
8	IN	SPENCER	6166	ROCKPORT	037 55 32	087 02 14	63,882
9	TX	TITUS	6147	MONTICELLO	033 05 30	095 02 30	62,526
10	TX	FORT BEND	3470	W A PARISH	029 29 00	095 37 59	62,274
11	IL	RANDOLPH	889	BALDWIN	038 12 18	089 51 16	61,352
12	GA	BARTOW	703	BOWEN	034 07 32	084 55 09	61,236
13	TN	STEWART	3399	CUMBERLAND	036 23 39	087 39 14	59,646
14	OH	GALLIA	8102	GEN J M GAVIN	038 56 09	082 06 59	59,512
15	OH	GALLIA	2876	KYGER CREEK	038 54 58	082 07 41	57,472
16	WV	PUTNAM	3935	JOHN E AMOS	038 28 29	081 49 30	57,296
17	MO	NEW MADRID	2167	NEW MADRID	036 30 54	089 33 41	56,763
18	AZ	COCONINO	4941	NAVAJO	036 54 45	111 23 30	56,332
19	MN	SHERBURNE	6090	SHERBURNE CNTY	045 22 50	093 22 52	56,210
20	PA	BEAVER	6094	BRUCE MANSFIELD	040 38 03	080 24 52	55,409
21	MT	ROSEBUD	6076	COLSTRIP	045 53 04	106 36 50	55,001
22	OH	JEFFERSON	2866	W H SAMMIS	040 31 58	080 37 59	54,171
23	WY	SWEETWATER	8066	JIM BRIDGER	041 45 00	108 48 00	53,894
24	WV	HARRISON	3944	HARRISON	039 23 00	080 19 00	51,050
25	FL	HILLSBOROUGH	645	BIG BEND	027 47 40	082 24 13	48,905
26	IL	CHRISTIAN	876	KINCAID	039 38 55	089 28 40	48,338
27	FL	CITRUS	628	CRYSTAL RIVER	028 57 59	082 41 49	48,230
28	PA	INDIANA	3122	HOMER CITY	040 30 51	079 11 49	47,834
29	IL	TAZEWELL	879	POWERTON	040 33 05	089 40 41	47,029
30	TX	FAYETTE COUNTY	6179	SAM SEYMOUR	029 55 02	096 45 02	46,212
31	WY	PLATTE	6204	LARAMIE RIVER	042 06 36	104 52 16	45,612
32	IA	WOODBURY	1091	GEORGE NEAL	042 19 00	096 22 00	45,359
33	NC	PERSON	2712	ROXBORO	036 29 00	079 04 29	45,297
34	OH	WASHINGTON-MORGAN	2872	MUSKINGUM RIVER	039 35 27	081 40 47	43,749
35	KS	LINN	1241	LA CYGNE	038 20 53	094 38 44	43,407
36	KS	POTTAWATOMIE	6068	JEFFREY ENERGY	039 17 08	096 06 36	43,337
37	GA	PUTNAM	709	HARLLEE BRANCH	033 11 39	083 17 58	41,771
38	NC	STOKES	8042	BELEWS CREEK	036 16 52	080 03 37	41,690
39	MI	ST CLAIR	6034	BELLE RIVER	042 46 32	082 29 42	40,934
40	PA	GREENE	3179	HATFIELD'S FERRY	039 51 00	079 55 00	39,639
41	FL	HILLSBOROUGH	646	F J GANNON	027 54 25	082 25 24	39,607
42	OH	JEFFERSON	2828	CARDINAL	040 15 08	080 38 55	38,897
43	MI	ST CLAIR	1743	ST CLAIR	042 45 52	082 28 16	38,859
44	MO	FRANKLIN	2103	LABADIE	038 33 30	090 50 10	38,775
45	AL	JEFFERSON	6002	JAMES H MILLER JR	033 37 58	087 03 32	38,747
46	MO	ST CHARLES	2107	SIOUX	038 54 57	090 17 30	37,470
47	UT	MILLARD	6481	INTERMOUNTAIN	039 30 39	112 34 45	36,654
48	WA	LEWIS	3845	CENTRALIA	046 42 00	122 51 00	36,401
49	AL	SHELBY	26	E C GASTON	033 14 39	086 27 24	35,647
50	IN	DEARBORN	988	TANNERS CREEK	039 04 59	084 51 29	34,949

Table II.6

1990 Interim Inventory
Top 50 Steam Utility SO_2 Emitters in 1990

Rank	State	County	Plant ID	Plant Name	Latitude	Longitude	Emissions (tpy)
1	OH	GALLIA	8102	GEN J M GAVIN	038 56 09	082 06 59	374,921
2	TN	STEWART	3399	CUMBERLAND	036 23 39	087 39 14	303,349
3	WV	HARRISON	3944	HARRISON	039 23 00	080 19 00	289,732
4	IN	JEFFERSON	983	CLIFTY CREEK	038 44 20	085 25 09	275,893
5	IN	GIBSON	6113	GIBSON	038 21 32	087 46 42	271,362
6	GA	BARTOW	703	BOWEN	034 07 32	084 55 09	255,407
7	MO	FRANKLIN	2103	LABADIE	038 33 30	090 50 10	249,870
8	OH	GALLIA	2876	KYGER CREEK	038 54 58	082 07 41	249,418
9	OH	WASHINGTON-MORGAN	2872	MUSKINGUM RIVER	039 35 27	081 40 47	240,870
10	IL	RANDOLPH	889	BALDWIN	038 12 18	089 51 16	230,525
11	GA	HEARD	6052	WANSLEY	033 25 00	085 02 00	223,964
12	KY	JEFFERSON	1364	MILL CREEK	038 03 11	085 54 36	211,073
13	OH	ADAMS	2850	J M STUART	038 38 14	083 41 44	180,603
14	PA	INDIANA	3118	CONEMAUGH	040 23 04	079 03 42	179,289
15	MO	NEW MADRID	2167	NEW MADRID	036 30 54	089 33 41	169,017
16	OH	JEFFERSON	2866	W H SAMMIS	040 31 58	080 37 59	168,581
17	IL	CHRISTIAN	876	KINCAID	039 38 55	089 28 40	166,399
18	PA	GREENE	3179	HATFIELD'S FERRY	039 51 00	079 55 00	163,432
19	OH	JEFFERSON	2828	CARDINAL	040 15 08	080 38 55	163,186
20	AL	SHELBY	26	E C GASTON	033 14 39	086 27 24	160,599
21	WV	MARSHALL	3947	KAMMER	039 50 47	089 49 08	155,374
22	FL	HILLSBOROUGH	645	BIG BEND	027 47 40	082 24 13	155,122
23	OH	LAKE	2837	EASTLAKE	041 40 15	081 28 45	144,581
24	PA	MONTOUR	3149	MONTOUR	041 04 12	076 39 59	142,681
25	WV	GRANT	3954	MT STORM	039 12 05	079 16 00	141,839
26	TN	SUMNER	3403	GALLATIN	036 18 56	086 24 02	140,997
27	KY	MUHLENBURG	1378	PARADISE	037 15 39	086 58 42	140,870
28	PA	ARMSTRONG	3136	KEYSTONE	040 39 09	079 20 31	134,849
29	MI	MONROE	1733	MONROE	041 53 28	083 20 40	128,514
30	PA	YORK	3140	BRUNNER ISLAND	040 08 00	076 43 00	128,160
31	IN	WARRICK	6705	WARRICK	037 54 55	087 20 01	122,923
32	IL	MASSAC	887	JOPPA STEAM	037 12 38	088 51 28	122,204
33	IN	VERMILLION	1001	CAYUGA	039 54 03	087 24 49	117,313
34	IL	MONTGOMERY	861	COFFEEN	039 03 31	089 24 11	114,315
35	OH	COSHOCTON	2840	CONESVILLE	040 11 10	081 52 44	113,636
36	AL	WALKER	8	GORGAS	033 38 39	088 11 50	113,412
37	PA	INDIANA	3122	HOMER CITY	040 30 51	079 11 49	109,448
38	OH	CLERMONT	2830	WALTER C BECKJORD	038 59 30	084 17 50	105,504
39	GA	COWETA	728	YATES	033 27 47	084 57 18	104,764
40	OH	HAMILTON	2832	MIAMI FORT	039 06 40	084 48 15	102,235
41	KY	CARROLL	1356	GHENT	038 44 59	085 02 06	100,790
42	IN	PIKE	994	PETERSBURG	038 31 42	087 15 08	100,173
43	GA	PUTNAM	709	HARLLEE BRANCH	033 11 39	083 17 58	99,818
44	FL	ESCAMBIA	641	CRIST	030 33 57	087 13 29	98,530
45	TN	ROANE	3407	KINGSTON	035 53 57	084 31 10	92,820
46	OH	LORAIN	2836	AVON LAKE	041 30 15	082 03 00	89,512
47	MS	HARRISON	2049	JACK WATSON	030 26 21	089 01 35	87,141
48	FL	CITRUS	628	CRYSTAL RIVER	028 57 59	082 41 49	86,823
49	TN	HUMPHREYS	3406	JOHNSONVILLE	036 01 40	087 59 10	86,687
50	MA	BRISTOL	1619	BRAYTON POINT	041 42 39	071 11 41	85,436

In 1990, as in 1985, the General Gavin plant in Ohio was the top SO_2 emitter. It was the 14th highest NO_x emitter in 1990. A Kentucky plant, Paradise, is the top NO_x emitter (and the 27th highest emitter of SO_2).

After generating the list of the top 50 utility SO_2 and NO_x emitters included in this chapter, comparisons of plant-level SO_2 and NO_x emission totals were made with a recent Aerometric Information Retrieval System (AIRS) Facility Subsystem summary of top emitters for these two pollutants. Comparisons were only made where plants had an AIRS year of record of 1990. Some large differences in annual emissions were found (up to 50,000 tons) between AIRS and 1990 Interim Inventory plant totals.

To investigate these large differences, the Kincaid Generating Station in Christian County, Illinois, was selected as a sample utility. This utility is included on the top 50 emitters list for both SO_2 and NO_x (Interim Inventory), and was on the AIRS list of top 30 NO_x-emitting facilities. AIRS and Interim Inventory plant emission totals for Kincaid are as follows:

Emissions	Interim 1990	AIRS
NO_x	48,338 tons	71,787 tons
SO_2	166,399 tons	125,404 tons

As it turns out, this is a relatively straightforward plant to analyze; it has two large coal-fired cyclone boilers (each of which burns a small amount of natural gas) and no SO_2 or NO_x control equipment.

Table II.7 shows the key operating statistics for Kincaid in 1990 as documented in the AIRS Facility Subsystem and the 1990 Interim Inventory. Natural gas fuel use and associated emissions are omitted from the table for simplicity. (The Form EIA-767 data for 1990 indicate that 66.2 million cubic feet of natural gas were consumed at the Kincaid plant. This results in less than 20 tons of NO_x.)

A key difference in the SO_2 emission estimates is the difference in estimated 1990 fuel consumption for Boiler 1. The AIRS coal consumption value is 27 percent lower than the 1990 Inventory value. (That was verified with the Form EIA-767 hard copy information for this facility.) Therefore, with the same emission factor and similar sulfur content, it would be expected that the AIRS SO_2 emissions would be lower than the Inventory's by about 27 percent, and in fact, it is.

Boiler 2 shows similar fuel use and sulfur content. The Interim Inventory assigns this boiler to the subbituminous coal SCC (based on the algorithm explained in Section A.2). The AP-42 subbituminous emission factor is smaller than the bituminous factor (the boiler is designated as bituminous in AIRS), so one would expect the Interim Inventory emissions to be lower than the AIRS estimate. In fact, the AIRS emissions are lower (66,000 tons) than the Interim Inventory estimate (85,000 tons). It is unclear as to how the AIRS SO_2 emissions were determined for Boiler 2.

NO_x emission calculations in AIRS are similarly difficult to comprehend. Emission calculations for both AIRS and the inventory use the same emission factor (37 lbs per ton of coal burned), so NO_x emission differences between the 1990 Inventory and AIRS should be proportional to fuel use differences. This is clearly not the case, since AIRS NO_x emissions are about 50 percent greater than that in the 1990 Inventory for both boilers,

Table II.7

Kincaid Generating Station -- Operating Statistics and Emission Estimates for 1990

	Coal Use (1,000 tons)	Coal Sulfur Content (%)	SO_2 Emission Factor*	NO_x Emission Factor	SO_2 Emissions (tons)	NO_x Emissions (tons)
Boiler ID 1						
Inventory 1990	1,196.4	3.47	39S	37	80,935	22,133
AIRS	870.7	3.40	39S	37	59,193	32,621
Boiler ID 2						
Inventory 1990	1,415.5	3.45	35S	37	85,464	26,186
AIRS	1,421.8	3.36	39S	37	66,208	39,100

NOTES: * The SO_2 emission factor is composed of a coefficient that is multiplied by the sulfur content. Emission factor units are pounds per ton.

while the AIRS fuel use for Boiler 1 is about 25 percent less than that for the Inventory, and the Boiler 2 use is similar for the two data sources.

D. PEAK-LOAD EMISSIONS

In addition to calculating annual electric utility emissions, a model was developed to estimate peak-load emissions caused by emergency power generation during periods of extreme weather conditions. The peak-load generation and emissions model (PEAKGEM) and its related software were developed to provide a modeling vehicle to estimate the amount and location of extra emissions of VOC, NO_x, CO, and SO_2 resulting from peak summer temperatures. PEAKGEM also models the impact of a cold winter season day. PEAKGEM is fully documented in a separate report (Pechan, 1992a).

CHAPTER III
POINT SOURCE EMISSIONS

Non-utility point source emissions in the Interim Inventories include emissions from all point sources except external combustion (steam) electric utility sources (see Chapter II). Electric utility internal combustion engines and gas turbines are included with this portion of the Interim Inventory because the 1985 NAPAP was the best source of readily available information on these emitters. Emissions from non-utility point sources were based on the 1985 NAPAP Inventory point source emissions (EPA, 1989a). NAPAP point source emissions were projected to the years 1987 through 1991 using BEA historical earnings data. This chapter describes the methodology used to estimate emissions, including computation of growth indicators, control efficiency revisions, and rule effectiveness assumptions.

A. GROWTH INDICATORS

Emission estimates from each point source in the 1985 NAPAP Inventory (excluding steam electric utilities) were projected to the years 1987 through 1991 based on the growth in earnings by industry (2-digit Standard Industrial Classification Code [SIC]). Historical earnings data from BEA's Table SA-5 (BEA, 1991a) were used to represent growth in earnings from 1985 through 1990. (Earnings data from a different BEA source, Table SQ-5 discussed below, were used to estimate 1991 emissions.) Table SA-5 historical annual earnings data are by State and industry.

The 1985 through 1990 earnings data in Table SA-5 were in nominal dollars. In order to be used to estimate growth, these values were converted to constant dollars to remove the effects of inflation. Earnings data for each year were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE)(BEA, 1991b). The PCE deflators used to convert each year's earnings data to 1982 dollars are:

Year	1982 PCE Deflator
1985	111.6
1987	114.3
1988	124.2
1989	129.6
1990	136.4

Several BEA categories did not contain a complete time series of data for the years 1985 through 1990. Since the SA-5 data must contain 1985 earnings and earnings for each inventory year (1987 through 1990) to be useful for estimating growth, a log linear regression equation was used to fill in missing data elements where possible. This regression procedure was performed on all categories that were missing at least one data point and which contain at least three data points in the time series.

Each record in the point source inventory was matched to the BEA earnings data based on the State and the 2-digit SIC. Table III.1 shows the BEA earnings category used to project growth for each of the 2-digit SICs found in the 1985 NAPAP Inventory. No growth in emissions was assumed for all point sources for which the matching BEA earnings data was not complete. Table III.2 shows the national average growth and earnings by industry from Table SA-5.

At the time the Interim Inventory was being compiled, 1991 BEA earnings data were not available in Table SA-5. Earnings data from BEA Table SQ-5 (BEA, 1992a) were used to estimate emissions for 1991. Table SQ-5 contains historical quarterly earnings data by State and 1-digit SIC. These data were converted to an annual constant dollars basis.

The 1991 quarterly earnings data were first summed to compute annual totals. Since the PCE deflator used to convert to constant 1982 dollars was not available for 1991, a 1987 PCE deflator (BEA, 1992b) was used to convert the 1990 and 1991 earnings data from Table SQ-5 to a 1987 constant dollar basis. The PCE deflators are:

Year	1987 PCE Deflator
1990	114.7
1991	119.3

The 1991 inventory was then developed by growing the 1990 inventory based on the changes in State industry earnings (by 1-digit SIC) from 1990 to 1991. National average growth in earnings by industry is shown below in Table III.3.

B. CONTROL EFFICIENCY REVISIONS

The 1985 NAPAP control efficiencies reported for Texas are much higher than the reported values in the rest of the inventory. The Texas control efficiencies for each pollutant were revised based on engineering judgement. Texas assigned the maximum control efficiency from a range of efficiencies for the given process/control device combination (Gill, 1992).

High control efficiencies lead to high future growth in modeling scenarios based on uncontrolled emissions (which are based on the control efficiency and reported actual emissions). High control efficiencies also lead to extreme increases in emission estimates when rule effectiveness is incorporated. Revised control efficiencies were developed for VOC for the Emission Reduction and Cost Analysis Model for VOC (ERCAM-VOC) (Pechan, 1988). For this analysis, revised efficiencies were also developed by SCC and control device combination for NO_x, SO_2, and CO using engineering judgement.

C. RULE EFFECTIVENESS ASSUMPTIONS AND EMISSION CALCULATIONS

Controlled emission estimates for each inventory year were recalculated, assuming that reported VOC, NO_x, and CO controls were 80 percent effective. SO_2 controls were assumed to be 100 percent effective. A three-step process was used to calculate emission

Table III.1

BEA Industry Earnings Data Classification

SIC	BEA Industry Earnings*
01	Farm
02	Farm
07	Agricultural services, forestry, fisheries, and other
08	Agricultural services, forestry, fisheries, and other
09	Agricultural services, forestry, fisheries, and other
10	Metal mining
11	Coal mining
12	Coal mining
13	Oil and gas extraction
14	Nonmetallic minerals, except fuels
15	Construction
16	Construction
17	Construction
20	Food and kindred products
21	Tobacco manufactures
22	Textile mill products
23	Apparel and other textile products
24	Lumber and wood products
25	Furniture and fixtures
26	Paper and allied products
27	Printing and publishing
28	Chemicals and allied products
29	Petroleum and coal products
30	Rubber and miscellaneous plastic products
31	Leather and leather products
32	Stone, clay, and glass products
33	Primary metal industries
34	Fabricated metal products
35	Machinery, except electrical
36	Electric and electronic equipment
37	Transportation equipment, excluding motor vehicles
38	Instruments and related products
39	Miscellaneous manufacturing industries
40	Railroad transportation
41	Local and interurban passenger transit
42	Trucking and warehousing
44	Water transportation
45	Transportation by air
46	Pipelines, except natural gas
47	Transportation services
48	Communication
49	Electric, gas, and sanitary services
50	Wholesale trade
51	Wholesale trade
52	Retail trade
53	Retail trade
54	Retail trade
55	Retail trade

Table III.1 (continued)

SIC	BEA Industry Earnings*
56	Retail trade
57	Retail trade
58	Retail trade
59	Retail trade
60	Banking and credit agencies
61	Banking and credit agencies
62	Holding companies and investment services
63	Insurance
64	Insurance
65	Real estate
66	Real estate
67	Holding companies and investment services
70	Hotels and other lodging places
72	Personal services
73	Business and miscellaneous repair services
75	Auto repair, services, and garages
76	Business and miscellaneous repair services
78	Amusement and recreation services and motion pictures
79	Amusement and recreation services and motion pictures
80	Health services
81	Legal services
82	Educational services
83	Social services and membership organizations
84	Miscellaneous professional services
86	Social services and membership organizations
88	Private households
89	Miscellaneous professional services
91	Federal government, civilian
92	State and local government
93	State and local government
94	State and local government
95	State and local government
96	State and local government
97	Federal government, civilian
371	Motor vehicles and equipment

NOTES: *State earnings by industry were matched to each of the 2- and 3-digit SICs to develop annual growth rates.

Table III.2

BEA SA-5 National Changes In Earnings By Industry

Industry	Percent Growth from: 1985 to 1987	1987 to 1988	1988 to 1989	1989 to 1990
Farm	14.67	-2.73	14.58	-3.11
Agricultural services, forestry, fisheries, and other	23.58	5.43	1.01	2.48
Coal mining	-17.46	-6.37	-4.16	4.73
Oil and gas extraction	-39.23	4.94	-3.88	5.16
Metal mining	-3.03	18.01	8.94	4.56
Nonmetallic minerals, except fuels	2.33	3.74	-2.79	-0.45
Construction	7.27	4.81	-1.36	-3.80
Manufacturing	-0.39	2.95	-0.97	-1.85
Nondurable goods	2.54	3.26	-0.67	-0.38
Food and kindred products	1.67	1.34	-1.20	-0.24
Textile mill products	8.50	-0.64	-1.39	-4.97
Apparel and other textile products	-1.72	1.25	-1.62	-4.22
Paper and allied products	2.62	0.94	-0.14	-0.39
Printing and publishing	7.44	5.67	-0.81	0.43
Chemicals and allied products	1.75	6.94	0.32	1.61
Petroleum and coal products	-10.82	-3.22	-3.02	1.06
Tobacco manufactures	-1.97	2.43	-2.43	-5.01
Rubber and miscellaneous plastic products	5.27	5.51	0.68	-0.14
Leather and leather products	-9.39	-1.64	-3.58	-2.55
Durable goods	-2.03	2.76	-1.14	-2.72
Lumber and wood products	10.03	5.15	-3.54	-3.71
Furniture and fixtures	6.82	2.35	-1.46	-2.98
Primary metal industries	-9.09	5.32	-0.34	-3.03
Fabricated metal products	-4.72	2.55	-0.86	-1.91
Machinery, except electrical	-5.72	6.02	-0.32	-1.92
Electric and electronic equipment	-3.17	-18.01	-1.91	-3.22
Transportation equipment, excluding motor vehicles	8.44	-1.57	0.55	-1.07
Motor vehicles and equipment	-6.45	2.20	-2.96	-5.43
Stone, clay, and glass products	-0.23	-1.61	-1.96	-3.19
Instruments and related products	-0.04	60.65	-0.82	-2.91
Miscellaneous manufacturing industries	1.84	6.92	-2.21	-2.54
Railroad transportation	-14.13	-2.53	-3.83	-6.03
Trucking and warehousing	5.63	3.26	-0.20	0.99

Table III.2 (continued)

Industry	Percent Growth from: 1985 to 1987	1987 to 1988	1988 to 1989	1989 to 1990
Water transportation	-8.92	0.07	-1.02	2.83
Local and interurban passenger transit	13.45	0.51	2.14	1.44
Transportation by air	12.01	4.63	4.94	4.36
Pipelines, except natural gas	-5.21	3.67	-4.93	3.53
Transportation services	15.92	8.52	4.60	4.97
Communication	1.94	0.68	-2.81	2.07
Electric, gas, and sanitary services	0.07	3.05	0.63	0.39
Wholesale trade	5.01	5.87	2.44	-1.02
Retail trade	5.19	4.39	0.65	-0.94
Banking and credit agencies	12.44	2.45	-0.33	-0.49
Insurance	14.09	4.20	1.52	2.71
Real estate	92.14	-6.98	-7.87	-0.48
Holding companies and investment services	39.05	-34.86	-12.18	16.91
Services	14.83	7.84	5.27	4.87
Hotels and other lodging places	12.65	5.59	1.71	2.29
Personal services	7.17	2.35	7.44	5.41
Private households	-5.68	2.41	0.83	-3.69
Business and miscellaneous repair services	17.05	-17.34	5.79	4.34
Auto repair, services, and garages	6.65	2.46	3.00	3.93
Amusement and recreation services and motion pictures	17.93	16.43	4.06	7.59
Health services	15.15	7.08	5.11	6.28
Legal services	20.14	9.92	4.09	4.80
Educational services	9.35	7.17	3.88	2.60
Social services and membership organizations	17.39	8.45	7.95	7.37
Miscellaneous professional services	11.28	5.04	7.08	4.12
Government and government enterprises	5.43	3.20	2.33	2.26
Federal, civilian	-0.54	3.79	1.21	1.96
Federal, military	1.96	-1.07	-1.58	-3.19
State and local	7.88	3.63	3.19	3.04

Table III.3

BEA SQ-5 National Growth In Earnings By Industry

Industry	Percent Growth from 1990 to 1991
Farm	-18.38
Agricultural services, forestry, fisheries, and other	-5.06
Coal mining	-0.75
Construction	-10.37
Manufacturing	-3.01
Nondurable goods	-0.89
Durable goods	-4.30
Wholesale trade	-2.55
Retail trade	-2.84
Services	1.91
Government and government enterprises	1.16
Federal, civilian	-0.49
Federal, military	-1.94
State and local	2.00

estimates incorporating rule effectiveness. First, base year controlled emissions are projected to the inventory year using the following formula:

$$CE_i = CE_{BY} + (CE_{BY} * EG_i) \tag{1}$$

where: CE_i = Controlled Emissions for inventory year i
CE_{BY} = Controlled Emissions for base year
EG_i = Earnings Growth for inventory year i

Earnings growth (EG) is calculated as:

$$EG_i = 1 - \frac{DAT_i}{DAT_{BY}} \tag{2}$$

where: DAT_i = Earnings data for inventory year i
DAT_{BY} = Earnings data in the base year

Second, uncontrolled emissions in the inventory year are back-calculated from the controlled emissions based on the control efficiency with the following formula

$$UE_i = \frac{CE_i}{(1 - CEFF/100)} \tag{3}$$

where: UE_i = Uncontrolled Emissions for inventory year i
CE_i = Controlled Emissions for inventory year i
CEFF = Control Efficiency (%)

Third, controlled emissions are recalculated incorporating rule effectiveness using the following formula:

$$CER_i = UC_i * \left(1 - \left(\frac{REFF}{100}\right) * \left(\frac{CEFF}{100}\right)\right) \tag{4}$$

where: CER_i = Controlled Emissions Incorporating Rule Effectiveness
UC_i = Uncontrolled Emissions
REFF = Rule Effectiveness (%)
CEFF = Control Efficiency (%)

D. EMISSION SUMMARY

Emission summary tables by major category for the non-utility point source inventory are shown in Table III.4. The emission summaries in Table III.4 represent emissions from non-utility point sources contained in the 1985 NAPAP Inventory, adjusted to subsequent inventory years. There are uncertainties associated with using this methodology to estimate point source emissions, however. The primary uncertainty related to this approach is that it does not consider plant shutdowns and new plant openings, which, if occurring after 1985, could increase or decrease the level of emissions estimated for subsequent inventory years. While the earnings-based growth indicators will account for growth/decline in industries, these factors will be applied to all sources within the State rather than accounting for individual plant openings/shutdowns.

Table III.4

Summary of National Non-Utility Point Source Emissions

Category	Emissions (thousand tons) 1987	1988	1989	1990	1991
VOC					
External Fuel Combustion - Industrial	216	230	222	221	223
External Fuel Combustion - Commercial/Institutional	3	3	3	3	3
Internal Combustion Engines	23	23	23	23	23
Chemical Manufacturing	2,001	2,206	2,176	2,190	2,220
Petroleum Refining	630	582	574	586	597
Primary and Secondary Metals	71	75	75	73	70
Mineral Products	18	18	18	17	17
Food and Agriculture Production	203	210	212	218	220
Misc. Industrial Processes	265	281	277	274	270
Industrial Organic Solvent Use	1,046	1,085	1,083	1,074	1,046
Petroleum Product Marketing	593	603	599	603	602
Organic Chemical Storage and Transportation	258	275	267	262	262
Waste Disposal	12	14	13	13	14
Total	5,338	5,603	5,542	5,557	5,567
NO_x					
External Fuel Combustion - Industrial	1,077	1,118	1,113	1,111	1,103
External Fuel Combustion - Commercial/Institutional	69	71	72	74	74
Internal Combustion Engines	616	635	622	637	634
Chemical Manufacturing	146	154	153	155	156
Petroleum Refining	201	198	191	194	196
Primary and Secondary Metals	61	66	67	65	63
Mineral Products	230	225	220	216	208
Food and Agriculture Production	5	5	5	5	5
Misc. Industrial Processes	182	185	185	187	187
Industrial Organic Solvent Use	8	8	8	8	7
Petroleum Product Marketing	1	1	1	1	1
Organic Chemical Storage and Transportation	0	0	0	0	0
Waste Disposal	17	18	19	19	19
Total	2,611	2,684	2,654	2,670	2,652

Table III.4 (continued)

Category	Emissions (thousand tons) 1987	1988	1989	1990	1991
CO					
External Fuel Combustion - Industrial	322	330	328	326	322
External Fuel Combustion - Commercial/Institutional	28	29	29	30	30
Internal Combustion Engines	177	178	176	176	174
Chemical Manufacturing	1,853	1,981	1,988	2,002	2,016
Petroleum Refining	1,947	1,858	1,819	1,876	1,875
Primary and Secondary Metals	2,988	3,165	3,188	3,107	2,970
Mineral Products	55	55	55	54	53
Food and Agriculture Production	0	0	0	0	0
Misc. Industrial Processes	761	763	766	768	761
Industrial Organic Solvent Use	2	2	2	2	2
Petroleum Product Marketing	1	1	1	1	1
Organic Chemical Storage and Transportation	0	0	0	0	0
Waste Disposal	74	77	77	77	75
Total	8,205	8,438	8,429	8,417	8,278
SO_2					
External Fuel Combustion - Industrial	1,987	2,035	2,025	2,020	1,991
External Fuel Combustion - Commercial/Institutional	181	190	195	200	202
Internal Combustion Engines	38	40	39	39	39
Chemical Manufacturing	471	499	483	483	486
Petroleum Refining	499	489	469	478	481
Primary and Secondary Metals	948	1,034	990	911	877
Mineral Products	278	271	264	259	250
Food and Agriculture Production	3	3	3	3	3
Misc. Industrial Processes	501	504	499	508	507
Industrial Organic Solvent Use	1	1	1	1	1
Petroleum Product Marketing	2	2	2	2	2
Organic Chemical Storage and Transportation	0	0	0	0	0
Waste Disposal	20	22	22	22	22
Total	4,931	5,089	4,990	4,926	4,860

CHAPTER IV
MOTOR VEHICLE EMISSIONS

Motor vehicle emissions in the 1990 Interim Inventory include all gasoline- and diesel-fueled highway vehicles. Two major groups of data were developed for the Interim Inventory. A 1990 VMT inventory was developed based on data from the Federal Highway Administration's (FHWA) Highway Performance Monitoring System (HPMS) (FHWA, 1992a). The 1990 VMT estimates were then adjusted to the other inventory years based on gasoline consumption data. EPA's MOBILE4.1 mobile source emission factor model (EPA, 1991c) was used to develop emission factors for each of the inventory years.

Two sets of emission factors were developed for each inventory year in the revised Interim Inventory. The first set was modeled with summer season Reid Vapor Pressure (RVP) levels and a wide range of temperatures. These emission factors were created for use as input to the Regional Oxidant Model (ROM) model. The second set of emission factors were modeled with RVPs for each season and average seasonal temperatures for each State. Together with the VMT estimates, these emission factors were used to calculate annual emission estimates. This chapter describes the methodologies used to develop VMT data, emission factors, and emission estimates.

A. BACKGROUND ON HPMS

1. Description of HPMS

HPMS is a national data collection and reporting system administered by FHWA in cooperation with State highway programs. HPMS contains data on the mileage, extent, and usage of the various functional road systems, the condition and performance of pavements, physical attributes of roads, road capacity and improvement needs, and other data important to the structural integrity and operation of the nation's road systems (FHWA, 1987a). The data that make up HPMS are submitted to FHWA annually by each State highway program.

HPMS has three main data components: (1) the universe data base, (2) the sample data base (a subset of the universe data base), and (3) the areawide data base. The universe data base contains a complete inventory of all mileage for all functional systems, except local roads. The sample data base contains more detailed information for a subset of the highway sections in the universe data base. Each record in the sample data base is part of a sample panel which can be expanded to represent the universe of highway mileage. The areawide data base contains annual State-level summaries of the major components of HPMS. Most of the State-level data in the areawide data base are divided into rural, small urban, and individualized urban area components. Table IV.1 illustrates the main data components of HPMS and the type of data they contain (FHWA, 1987a).

Table IV.1

Data Components of HPMS

Universe - All Road Mileage

Identification	Contains State, county, and rural/small urbanized codes and a unique identification of location reference. Optionally, the latitude and longitude coordinates for the beginning and ending points of universe and sample sections are provided.
System	Provides for coding of functional system and Federal-aid system.
Jurisdiction	Provides for coding of State or local highway system and special funding category.
Operation	Includes type of facility, truck prohibition, and toll.
Other	Contains length of highway section and fields for the coding of AADT and the number of through lanes.

Sample - Statistical Sample of Universe

Identification	Contains unique identification for the sample section portion of the record.
Computational Elements	Provides data items used to expand sample information to universe values.
Pavement Attributes	Contains data items used to evaluate the physical characteristics of pavement, pavement performance, and the need for pavement overlays.
Improvements	Describes the improvement type for the year of the improvement completion.
Geometrics/Configuration	Describes the physical attributes used to evaluate the capacity and operating characteristics of the facility.
Traffic/Capacity	Provides operational data items used to calculate the capacity of a section and the need for improvements.
Environment	Contains items that marginally affect the operation of a facility but are important to its structural integrity.
Supplemental Data	Provides linkage to existing structure and railroad crossing information systems.

Areawide - State Summaries

Mileage	Road mileage
Travel	Vehicle miles traveled, percent travel by vehicle type
Accidents	Number of accidents
Injuries	Number of injuries
Population	Area population

The travel data in HPMS are of great interest in estimating VMT. HPMS travel data are based on samples of daily traffic counts taken at various points in a State's roadway network. These daily traffic counts are expanded to annual average daily traffic (AADT). To calculate VMT for a specific section of road, the AADT for that section of road is multiplied by the road length (FHWA, 1985).

HPMS also includes an analysis component which uses a series of computer programs to analyze the data furnished by the States. The impact analysis (one of several different analyses in the analysis component) provides a comparison of vehicle performance measures under different scenarios. One of the performance measures in the impact analysis is average overall travel speed (FHWA, 1987b). The average overall travel speed output from the HPMS impact model was used as the basis for determining the distribution of speeds to use in estimating emissions. The impact analysis average overall speed output and the derivation of the speeds used to model emissions will be discussed later in this chapter.

2. *Rationale for Using HPMS to Estimate VMT*

There are two primary reasons for using HPMS data to estimate VMT. First, HPMS has the best available VMT data for 1990. HPMS is a source of consistent VMT data from States. Integrity of the data, which is consolidated in a single source, has been checked at both the State and Federal (FHWA) level. Second, EPA has directed States to use HPMS to estimate VMT for their 1990 State Implementation Plan (SIP) inventories. The use of HPMS data to estimate VMT for the 1990 Interim Inventory closely approximates the methods that will be used in the 1990 SIP inventories, and will therefore yield VMT estimates that are consistent with those in SIP inventories.

3. *Problems with Using HPMS to Estimate VMT*

There are several complexities associated with using HPMS data to estimate VMT for this inventory. The county is the basic geographic unit in the 1990 Interim Inventory, while all data in HPMS are divided into rural, small urban, and individualized urban geographic areas. In order to use the HPMS data, a mechanism to distribute VMT from a rural, small urban, and individual urban area level to a county level had to be developed. In addition, the level of detail of reporting in the sample data base (the most detailed data base which contained VMT information) varied from State to State. Some States reported data for each individual urban area, some States reported data for all individual urban areas together, and some States reported data separately for some individual urban areas and reported data for the remaining individual urban areas together. This made distributing VMT from the sample data base to counties a difficult task. In the areawide data base, however, all States reported data for individual urban areas separately. Finally, travel data for local road systems were only contained in the areawide data base. Given the problems described above and the limited timeframe of the project, the areawide data base was used to generate county-level VMT estimates. The methodology used to generate county-level VMT estimates is described below.

B. GENERATION OF VMT ESTIMATES

County-level VMT estimates for 1990 were developed based on VMT data from the 1990 HPMS areawide data base. The HPMS areawide data base contains estimates of daily VMT for each State. For each State, the HPMS areawide data base contains estimates (segregated by functional road system) of daily VMT for all travel in rural areas, estimates of daily VMT for all travel in small urban areas, and separate estimates of daily VMT for travel in each of the State's large urbanized area.

Three procedures had to be performed to the HPMS VMT in order for it to be used in the Interim Inventory. First, the rural, small urban, and large urban 1990 VMT in each State had to be distributed to the counties in that State based on population data. Second, 1990 county-level VMT estimates had to be allocated to the six vehicle types used in the AIRS-Area and Mobile Source Subsystem (AIRS-AMS) based on HPMS and other FHWA data. Finally, the 1990 county-level VMT estimates were adjusted to the other inventory years based on gasoline consumption data (DOE, 1991a). The methods used to perform each of these three procedures are described below.

1. Distribution of HPMS VMT to Counties

VMT from the HPMS areawide data base was distributed to counties based on each county's rural, small urban, and urbanized area population. Two tables in the Bureau of the Census 1980 Number of Inhabitants (CNOI) documents (BOC, 1983) were used as the source for population data. The 1980 population data had to be used to allocate the VMT because the Census Urbanized Area boundaries were changed for the 1990 census. Although not exactly the same, the large urban area boundaries used in HPMS are based on the 1980 Census Urbanized Area boundaries. Use of the 1990 Census Urbanized Area boundaries would prevent a one-to-one match between HPMS large, urban-area VMT and urbanized area population, making VMT distribution difficult.

The two CNOI tables used to distribute VMT to counties are:

- **Table 3: Population of Counties by Urban and Rural Residence**. This table lists the urban population living inside census-defined urbanized areas, the urban population living outside census-defined urbanized areas, and the rural population for each county.

- **Table 13: Population of Urban Areas**. This table divides an urbanized area's population among the counties that contain portions of that urbanized area.

County-level rural VMT, small urban VMT, and urbanized area VMT were calculated separately using the following methodology. The methodology described below was performed for each functional road system.

a. Rural VMT

1. Calculate the percentage of the State's rural population in each county using county rural population data from CNOI Table 3.

2. Calculate each county's rural VMT by distributing State rural VMT from the HPMS areawide data base, based on the percentage of the State's rural population in each county using the following equation:

$$VMT_{R,C}=VMT_{R,S}*\frac{POP_{R,C}}{POP_{R,S}} \tag{1}$$

where: $VMT_{R,C}$ = Rural VMT in county C (calculated)
$VMT_{R,S}$ = Rural VMT, State total (HPMS)
$POP_{R,C}$ = Rural population in county C (CNOI)
$POP_{R,S}$ = Rural population, State total (CNOI)

b. Small Urban VMT

1. Calculate the percentage of the State's small urban population in each county using county urban population living outside census-defined urbanized areas from CNOI Table 3.

2. Calculate each county's small urban VMT by distributing State small urban VMT from the HPMS areawide data base based on the percentage of the State's small urban population in each county using the following equation:

$$VMT_{SU,C}=VMT_{SU,S}*\frac{POP_{SU,C}}{POP_{SU,S}} \tag{2}$$

where: $VMT_{SU,C}$ = Small urban VMT in county C (calculated)
$VMT_{SU,S}$ = Small urban VMT, State total (HPMS)
$POP_{SU,C}$ = Small urban population in county C (CNOI)
$POP_{SU,S}$ = small urban population, State total (CNOI)

c. Urban Area VMT

1. For each urbanized area, calculate the percentage of its population in each county containing a portion of the urbanized area using data from CNOI Table 13.

2. Calculate each county's share of an urban area's VMT by distributing urban area VMT from the HPMS areawide data base based on the percentage of the urban area's population in each county using the following equation:

$$VMT_{UA,C}=VMT_{UA,S}*\frac{POP_{UA,C}}{POP_{UA,S}} \tag{3}$$

where: $VMT_{UA,C}$ = Urban area's VMT in county C (calculated)
$VMT_{UA,S}$ = Urban area's VMT, State total (HPMS)
$POP_{UA,C}$ = Urban area's population in county C (CNOI)
$POP_{UA,S}$ = Urban area's population, State total (CNOI)

In a few cases, a single county contained parts of more than one urban area. For those counties, urban VMT was calculated as the sum of the county's proportion of VMT from each of the large urban areas in the county and the county's small urban VMT.

2. *Allocation of VMT to the AIRS-AMS Vehicle Types*

The VMT estimates in the HPMS data base are not divided by vehicle type. In order for motor vehicle emission estimates to be separated into the appropriate AMS source categories, VMT estimates were distributed to six different vehicle types: light-duty gasoline vehicles (LDGV), light-duty gasoline trucks (LDGT), heavy-duty gasoline vehicles (HDGV), light-duty diesel vehicles (LDDV), light-duty diesel trucks (LDDT), and heavy-duty diesel vehicles (HDDV). For each of the 6 AMS vehicle types, emissions are further divided into 12 roadway types. Therefore, each county's VMT estimates are divided into 72 AMS categories. Table IV.2 lists the 6 AMS vehicle types and the 12 roadway types used in this inventory. Below is the methodology for allocating VMT among these six different vehicle types for the 1990 Interim Inventory.

The primary data sources used in this methodology were the HPMS areawide data base and the Bureau of the Census Truck Inventory and Use Survey (TIUS)(BOC, 1990). In addition, travel data from the MOBILE4 Fuel Consumption Model was used to divide LDV VMT into its gasoline and diesel components (EPA, 1989b).

The HPMS areawide data base contains travel activity by vehicle type and functional system (expressed as a percentage of travel) for each State. These data served as the basis for the vehicle type distribution. The problem with these data is that the vehicle type categories used are different from the AMS source categories. The vehicle type categories in HPMS are:

- motorcycles
- passenger cars
- other 2-axle, 4-tire, single-unit vehicles
- buses
- 2-axle 6-tire, single-unit vehicles
- 3-axle, single-unit trucks
- four or more axle, single-unit trucks
- four or fewer axle, single-trailer trucks
- 5-axle, single-trailer trucks
- six or more axle, single-trailer trucks
- five or fewer axle, multi-trailer trucks
- 6-axle, multi-trailer trucks
- seven or more axle, multi-trailer trucks

The following three steps redistributed the HPMS travel activity data into the AMS source categories. The steps below were repeated for each State, and the resulting data reflect travel activity percentages by AMS source category and functional system for each State. These numbers were then applied to the county-level VMT estimates to obtain the final VMT estimates needed for the inventory.

a. *Calculate LDGV and LDDV Travel Percentages*

The HPMS passenger car travel activity category was assumed to match the AMS light-duty vehicle (LDV) categories. Therefore, the only calculation required to calculate travel activity for the LDGV and LDDV categories was to divide the passenger car travel activity into its gasoline and diesel components. Distribution of LDV travel to gasoline and diesel vehicles was estimated using data from EPA's MOBILE4 Fuel Consumption Model (EPA, 1989b). Specifically, the distribution was calculated using the

Table IV.2

AMS Vehicle/Road Types

VEHICLE TYPES
Light-Duty Gasoline Vehicle (LDGV)
Light-Duty Gasoline Truck (LDGT)
Heavy-Duty Gasoline Vehicle (HDGV)
Light-Duty Diesel Vehicle (LDDV)
Light-Duty Diesel Truck (LDDT)
Heavy-Duty Diesel Vehicle (HDDV)

ROAD TYPES	
Interstate:	Rural
Other Principal Arterial:	Rural
Minor Arterial:	Rural
Major Collector:	Rural
Minor Collector:	Rural
Local:	Rural
Interstate:	Urban
Other Freeway & Expressways:	Urban
Other Principal Arterial:	Urban
Minor Arterial:	Urban
Collector:	Urban
Local:	Urban

fuel consumption model's estimates of 1990 gasoline and diesel VMT using the following formulas:

$$LDGV_{s,f}=PC_{s,f}*\frac{LDGVVMT}{LDVVMT} \tag{4}$$

$$LDDV_{s,f}=PC_{s,f}*\frac{LDDVVMT}{LDVVMT} \tag{5}$$

where:	$LDGV_{s,f}$	=	Percentage of travel by LDGVs in State *s* on functional system *f* (calculated)
	$LDDV_{s,f}$	=	Percentage of travel by LDDVs in State *s* on functional system *f* (calculated)
	$PC_{s,f}$	=	Percentage of travel by passenger cars in State *s* on functional system *f* (HPMS)
	LDGVVMT	=	1990 national LDGV VMT (MOBILE4 FCM)
	LDDVVMT	=	1990 national LDDV VMT (MOBILE4 FCM)
	LDVVMT	=	1990 national LDV VMT (MOBILE4 FCM)

In 1990, 98.4 percent of the LDV travel was by LDGVs and 1.6 percent was by LDDVs.

b. Divide Truck Travel into its Light- and Heavy-Duty Components

The travel activity of the remaining 11 HPMS vehicle type categories (motorcycles are not included in the inventory) was distributed to the light-duty truck (LDT) and heavy-duty vehicle (HDV) categories using data from Table 11 of the TIUS. Table 11 contains data on truck miles by vehicle size, truck type and axle arrangement. The TIUS uses the following categories for vehicle size:

- light - average vehicle weight of 10,000 lbs or less
- medium - average vehicle weight of 10,001 to 19,500 lbs
- light-heavy - average vehicle weight of 19,501 to 26,000 lbs
- heavy-heavy - average vehicle weight of 26,001 lbs or more

These categories do not match the definitions used by AMS. In AMS, a LDT is defined as any motor vehicle rated at 8,500 lbs gross vehicle weight rating (GVWR) or less, and has a vehicle curb weight of 6,000 lbs or less. By using the TIUS light truck definition LDT travel activity was slightly overestimated and HDV travel activity was slightly underestimated because travel by trucks in the 8,500 to 10,000 lbs range was included in the LDT travel activity.

The TIUS divides truck miles among these categories for the following truck type and axle arrangements:

- 2-axle, single-unit trucks
- 3-axle, single-unit trucks
- four or more axle, single-unit trucks

- 3-axle, truck-tractor with single trailer
- 4-axle, truck-tractor with single trailer
- five or more axle, truck-tractor with single trailer
- 5-axle, truck-tractor with double trailers
- 6-axle, truck-tractor with double trailers
- seven or more axle, truck-tractor with double trailers

(These categories match closely with the HPMS categories and were used to easily distribute travel activity for HPMS categories that contain some LDT and some HDV travel activity.)

Table IV.3 shows how the travel activity for the remaining HPMS vehicle type categories was distributed. For the HPMS vehicle type categories listed in Table IV.3 as having its travel activity distributed based on TIUS Table 11, the following formulas were used:

$$LDT_{s,f,H}=PT_H*\frac{LTM_{ta}}{TTM_{ta}} \tag{6}$$

$$HDV_{s,f,H}=PT_H-LDT_{s,f,H} \tag{7}$$

where: $LDT_{s,f,H}$ = Percentage of LDT travel in State *s* on functional system *f* by HPMS vehicle type *H* (calculated)

$HDV_{s,f,H}$ = Percentage of HDV travel in State *s* on functional system *f* by HPMS vehicle type *H* (calculated)

$PT_{s,f,H}$ = Percentage of travel in State *s* on functional system *f* by HPMS vehicle type *H* (HPMS)

LTM_{ta} = Truck miles for light trucks for truck type and axle arrangement *ta* (TIUS)

TTM_{ta} = Total truck miles for truck type and axle arrangement *ta*

To obtain the total percentage of LDT and HDV travel by State and functional system, the travel percentages calculated above were summed using the following formulas:

$$LDT_{s,f}=\sum_{H=1}^{11} LDT_{s,f,H} \tag{8}$$

$$HDV_{s,f}=\sum_{H=1}^{11} HDV_{s,f,H} \tag{9}$$

where: $LDT_{s,f}$ = Total percentage of LDT travel in State *s* on functional system *f* by HPMS vehicle type *H* (calculated)

$HDV_{s,f}$ = Total percentage of HDV travel in State *s* on functional system *f* by HPMS vehicle type *H* (calculated)

$LDT_{s,f,H}$ = Percentage of LDT travel in State *s* on functional system *f* by HPMS vehicle type *H* (calculated in equation 6)

$HDV_{s,f,H}$ = Percentage of HDV travel in State *s* on functional system *f* by HPMS vehicle type *H* (calculated in equation 7)

Table IV.3

Distribution of Truck Travel Activity

HPMS Vehicle Type Category	Distribution of Travel Activity
Other 2-axle, 4-tire, single unit vehicles	Distribution to LDT and HDV based on TIUS Table 11
Buses	All HDV
2-axle, 6-tire, single unit vehicles	Distribution to LDT and HDV based on TIUS Table 11
3-axle, single-unit trucks	Distribution to LDT and HDV based on TIUS Table 11
4 or more axle single-unit trucks	Distribution to LDT and HDV based on TIUS Table 11
four or fewer axle, single trailer trucks	Distribution to LDT and HDV based on TIUS Table 11
5-axle, single-trailer trucks	Distribution to LDT and HDV based on TIUS Table 11
six or more axle, single-trailer trucks	Distribution to LDT and HDV based on TIUS Table 11
five or fewer axle, multi-trailer trucks	All HDV*
6-axle, multi-trailer trucks	All HDV*
seven or more axle, multi-trailer trucks	All HDV*

NOTES: *100 percent of truck miles in TIUS Table 11 in HDV categories.

c. *Divide LDT and HDT Travel into its Gasoline and Diesel Components*

The final step was to divide the travel activity percentages calculated in Step 2 into gasoline and diesel components. TIUS Table 11 also contains data on truck miles by vehicle size and engine type. The percentage of travel activity distributed to gasoline and diesel was based upon the proportion of gasoline and diesel truck miles reported in Table 11 for LDTs and HDVs, respectively. The following formulas were used to calculate the gasoline and diesel components of truck travel:

$$LDGT_{s,f} = LDT_{s,f} * \frac{LGTM}{LTTM} \tag{10}$$

$$LDDT_{s,f} = LDT_{s,f} * \frac{LDTM}{LTTM} \tag{11}$$

$$HDGV_{s,f} = HDV_{s,f} * \frac{HGTM}{HTTM} \tag{12}$$

$$HDDV_{s,f} = HDT_{s,f} * \frac{HDTM}{HTTM} \tag{13}$$

where:

LDGTs,f	=	Total percentage of LDGT travel in State *s* on functional system *f* (calculated)
LDDTs,f	=	Total percentage of LDDT travel in State *s* on functional system *f* (calculated)
$LDT_{s,f}$	=	Total percentage of LDT travel in State *s* on functional system *f* by HPMS vehicle type *H* (calculated in equation 8)
$HDV_{s,f}$	=	Total percentage of HDV travel in State *s* on functional system *f* by HPMS vehicle type *H* (calculated in equation 9)
LGTM	=	Truck miles for light gasoline trucks (TIUS)
LDTM	=	Truck miles for light diesel trucks (TIUS)
LTTM	=	Total truck miles for light trucks (TIUS)
HGTM	=	Truck miles for heavy gasoline trucks (TIUS)
HDTM	=	Truck miles for heavy diesel trucks (TIUS)
HTTM	=	Total truck miles for heavy trucks (TIUS)

The travel percentages by functional system and vehicle type for each State calculated using the above methodology were then applied to the 1990 county-level VMT estimates resulting in 1990 county-level VMT estimates for each motor vehicle AMS SCC. County-level VMT estimates were thus produced for each of the AMS categories shown in Table IV.2.

3. *Projecting VMT to Other Inventory Years*

The 1990 county-level VMT was adjusted to the other inventory years based on State Energy Data System (SEDS) gasoline consumption data (DOE, 1991a). SEDS contains annual motor gasoline consumption data for each State. At the time the Interim Inventory was developed, 1989 was the latest year for which SEDS data existed. The

1990 and 1991 State motor gasoline consumption was projected using 1985 through 1989 SEDS gasoline consumption data with the following log linear regression equation:

$$y = a_0 * e^{(a_1 * t)} \tag{14}$$

Average miles per gallon (mpg) estimates from the MOBILE4 Fuel Consumption Model (EPA, 1989b) were then applied to each State's gasoline consumption in each inventory year resulting in VMT estimates for the years 1987 through 1991. The mpgs used in this calculation were:

Year	Average mpg
1987	15.14
1988	15.44
1989	15.73
1990	15.98
1991	16.21

These VMT estimates were used to adjust the 1990 VMT to the other inventory years. These State-level growth figures were then applied to the 1990 VMT (calculated from the HPMS data) which produced VMT estimates for the other inventory years. Table IV.4 lists the national VMT estimates for the years 1987 through 1991.

C. EMISSION FACTOR CALCULATION

Two sets of motor vehicle emission factors were developed for the years 1987 through 1991. The first set, described below, was developed for input to the Flexible Regional Emissions Data System (FREDS). The second set, described later in this chapter, was developed for use in creating a separate but consistent data base with annual and seasonal estimates of motor vehicle emissions.

EPA's MOBILE4.1 mobile source emission factor model was used to calculate all emission factors (EPA, 1991c). The November 4, 1991, version of MOBILE4.1 was used for this inventory. The pollutants modeled were exhaust nonmethane organic gas (NMOG), evaporative NMOG (which includes resting loss, running loss, and evaporative emissions), exhaust NO_x, and exhaust CO. NMOG emissions include ethane and aldehydes in addition to Flame Ionization Detector (FID) measured hydrocarbons.

Nine speeds and 60 temperatures were modeled for each State. The nine speeds used in the model were derived from the average overall speed output from the HPMS impact analysis. Average overall speed data were obtained for the years 1987 through 1990 (1991 was not yet available) (FHWA, 1992b). The average overall speed for each vehicle type varied less than one mile per hour (MPH) over the 4-year span. Therefore, the same speeds (from 1990) were used for all years. Table IV.5 lists the average overall speed output for 1990 from the HPMS impact analysis. To determine the actual speeds to use in modeling the emission factors, HPMS vehicle types were chosen to represent the speeds for each AMS vehicle type:

- passenger cars -- used for LDVs (speeds for small and large cars were the same)
- pickup trucks and vans -- used for LDTs
- multi-trailer trucks with five or more axles -- used for HDVs

Table IV.4

National VMT Estimates

Year	VMT (millions)
1987	1,897,412
1988	1,997,672
1989	2,036,376
1990	2,145,859
1991	2,228,069

Table IV.5

HPMS Average Overall Travel Speeds for 1990
(MPH)

	Rural					Urban				
Vehicle Type	Interstate	Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Interstate	Other Freeways Expressways	Principal Arterial	Minor Arterial	Collector
Small Pass. Cars	58.4	46.5	40.1	35.4	30.3	46.3	42.4	18.7	19.3	19.5
Large Pass. Cars	58.4	46.5	40.1	35.4	30.3	46.3	42.4	18.7	19.3	19.5
Pickups & Vans	56.7	45.6	39.7	35.3	30.5	45.4	41.9	19.5	20.1	20.3
Single 2 Axle	55.7	44.5	38.8	32.6	24.1	47.1	42.9	18.1	18.2	18.0
Single 3+ Axle	53.3	43.0	37.6	33.1	29.8	45.4	41.5	18.0	18.1	18.1
Multi 4+ Axle	43.0	34.0	30.7	27.9	25.7	37.2	34.4	14.7	14.6	14.5
Multi 5+ Axle	41.8	33.4	30.2	26.9	22.5	36.4	33.8	14.6	14.5	14.3

To reduce the number of speeds to be modeled, the HPMS speeds were rounded to the nearest 5 miles per hour. Local speeds, which were not included in the HPMS impact analysis output, were assumed to be the same as minor collector speeds for rural roads and collector speeds for urban roads. Table IV.6 lists the average speed used for each road type/vehicle type combination.

Each of the nine speeds was modeled at mean temperatures varying from 40°F to 95°F in 5° intervals. Each mean temperature was modeled with diurnal ranges of 0°F, 10°F, 20°F, 30°F, and 40°F. The Federal Test Procedure (FTP) operating mode was modeled in all cases, with 20.6 percent of VMT accumulated in cold-start mode, 27.3 percent of VMT accumulated in hot-start mode, and 52.1 percent of VMT accumulated in stabilized mode.

Each State's emission factors were modeled at the hot summer season RVP level for the year being modeled. RVP values for each year were developed using data from that year's summer Motor Vehicle Manufacturers Association (MVMA) Fuel Volatility Survey (MVMA, 1990). 1991 RVPs were assumed to be the same as 1990 RVPs, because data from the 1991 MVMA survey were not yet available at the time the emission factors were developed.

The following procedure was used to develop one representative summer RVP for each State to be used in the emission factor modeling. Twenty-three cities were included in the MVMA surveys. EPA's Office of Mobile Sources (OMS) provided a listing that matched the surveyed cities to a larger number of MSAs according to pipeline distribution maps (Wolcott, 1992). States that had only one MSA in the OMS listing were assigned that MSA's RVP for the whole State. For States containing more than one MSA in the OMS listing, the mean RVP of all MSAs in the State was assigned to the whole State. For States not containing any MSAs in the OMS listing, the RVP of the closest MSA in the OMS listing was assigned to the whole State. Table IV.7 lists each State's summer RVP values based on the OMS listing used to estimate emission factors in each inventory year.

A second group of emission factors modeled with the above parameters was run for each State with an inspection and maintenance (I/M) program in place in some or all of its counties in the respective inventory years. The determination of whether or not a county had an I/M program in place in a given year was based on an EPA report of I/M program implementation status (EPA, 1991d). Emission factors calculated with I/M benefits in a given inventory year were applied only to counties having an I/M program in place in December of the prior year. I/M program characteristics were also supplied by EPA (EPA, 1991d). These program characteristics vary by State and in some cases by substate areas. The effectiveness statistics used as MOBILE4.1 inputs varied by State based on the characteristics of representative I/M programs in that State. For States where I/M programs vary by substate regions, a single set of effectiveness statistics based on a combination of characteristics of all the I/M programs were used as inputs to the model.

D. CALCULATION OF MOTOR VEHICLE EMISSIONS

Motor vehicle emissions were estimated for each inventory year using State-specific seasonal emission factors and the VMT estimates described earlier in the chapter. Seasonal changes in temperature, gasoline RVP, and travel activity have a large impact on motor vehicle emissions. In order to accurately estimate annual motor vehicle emissions, these variations in emission factors by season were incorporated into the calculation. Seasonal VMT was estimated using the temporal allocation factors developed

Table IV.6

Average Speeds by Road Type and Vehicle Type (MPH)

	Rural						Urban					
	Interstate	Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Local	Interstate	Other Freeways & Espressways	Principal Arterial	Minor Arterial	Collector	Local
LDV	60	45	40	35	30	30	45	45	20	20	20	20
LDT	55	45	40	35	30	30	45	45	20	20	20	20
HDV	40	35	30	25	25	25	35	35	15	15	15	15

Table IV.7

Summer RVPs Used to Model Motor Vehicle Emission Factors

	State Reid Vapor Pressure (psi)				
State	1987	1988	1989	1990	1991
AL	10.60	10.20	8.47	8.29	8.29
AZ	8.77	8.33	8.20	8.05	8.05
AR	10.00	9.70	8.73	8.43	8.43
CA	8.71	8.52	8.37	8.10	8.10
CO	10.00	9.33	8.67	8.40	8.40
CT	10.80	11.00	8.55	8.40	8.40
DE	11.10	10.90	8.79	8.35	8.35
DC	11.00	10.90	9.05	8.35	8.35
FL	10.20	10.50	8.92	9.15	9.15
GA	10.60	10.70	8.60	8.47	8.47
ID	10.10	9.98	9.59	9.06	9.06
IL	11.60	11.00	9.62	8.65	8.65
IN	11.60	11.00	9.62	8.65	8.65
IA	11.10	10.50	9.72	9.45	9.45
KS	9.80	9.40	8.60	8.43	8.43
KY	11.60	10.90	9.28	8.59	8.59
LA	10.50	10.90	8.50	8.27	8.27
ME	10.80	11.00	8.55	8.40	8.40
MD	11.00	10.90	9.05	8.35	8.35
MA	10.80	11.00	8.55	8.40	8.40
MI	11.60	11.00	9.74	8.93	8.93
MN	10.50	10.50	9.72	9.45	9.45
MS	10.10	10.30	8.43	8.19	8.19
MO	10.10	10.00	8.92	8.60	8.60
MT	9.10	9.50	9.27	8.60	8.60
NE	10.20	10.00	9.12	8.95	8.95
NV	8.63	8.37	8.05	8.25	8.25
NH	10.80	11.00	8.55	8.40	8.40
NJ	11.30	10.90	9.22	8.37	8.37
NM	9.50	8.50	8.20	8.10	8.10
NY	11.20	11.00	8.52	8.20	8.20
NC	10.60	10.70	8.60	8.47	8.47
ND	10.50	10.50	9.72	9.45	9.45
OH	11.60	11.40	9.82	9.71	9.71
OK	10.00	9.90	8.54	8.16	8.16
OR	11.10	10.45	9.90	9.52	9.52
PA	11.30	10.90	9.32	8.60	8.60
RI	10.80	11.00	8.55	8.40	8.40
SC	10.60	10.70	8.60	8.47	8.47
SD	10.50	10.50	9.72	9.45	9.45
TN	10.50	10.70	8.57	8.40	8.40
TX	9.00	9.50	8.39	8.12	8.12
UT	10.00	9.33	8.67	8.40	8.40
VT	10.70	11.00	8.55	8.40	8.40
VA	11.00	10.90	9.05	8.35	8.35
WA	11.10	10.45	9.90	9.52	9.52
WV	11.00	11.00	9.30	8.82	8.82
WI	11.60	11.00	9.62	8.65	8.65
WY	9.55	9.42	8.97	8.50	8.5

NOTES: Developed from July MVMA Fuel Volatility Surveys for the 1985 NAPAP Inventory (EPA, 1990). Seasonal emission factors were calculated for each State based on temperature and gasoline RVP. Annual motor vehicle emissions for each State were calculated as the sum of the seasonal emissions. The remainder of this chapter describes in detail the procedures used to calculate motor vehicle emissions.

1. Seasonal Emission Factors

The seasonal emission factors created to compute motor vehicle emissions were calculated using MOBILE4.1 The inputs to MOBILE4.1 for the seasonal emission factors were the same as those used to calculate the emission factors for input to FREDS (described earlier in this chapter) with three exceptions. First, exhaust and evaporative VOC rather than NMOG were modeled. MOBILE4.1 defines VOC as nonmethane hydrocarbons minus ethane corrected for aldehydes (EPA, 1991c). Second, the seasonal emission factors were calculated for each State based on season-specific gasoline RVP. Third, the seasonal emission factors were calculated for each State based on season specific temperatures. The procedures developed for estimating seasonal gasoline RVP values and seasonal average maximum and minimum temperatures for each State are described below.

a. Seasonal Gasoline RVP

This section describes the methodology used to apportion RVP values to each State by season for 1987 through 1991. The steps involved in making these calculations were: (1) determine the weighted July and January RVP for the 23 MVMA survey cities in each of the 5 years, (2) assign a July and January RVP to each State for each of the 5 years, (3) estimate the RVP for the other months for each State and each year, and (4) average the monthly RVP values to obtain seasonal RVP values for each State and year.

In step 1, data from the MVMA fuel volatility surveys for 1987 through 1991 were used (MVMA, 1987-1991). The basic MVMA data included average January and July RVP values for regular unleaded, intermediate, and premium unleaded gasoline in the 23 survey cities. Data for all three of these fuel types were not available for all 23 survey cities, but each city had, at a minimum, RVP data for regular unleaded gasoline in January and July. According to guidance issued in support of SIP emission inventories, if the RVP for all three fuel types was given in the survey, the weighted RVP was calculated as 50 percent of the RVP of regular unleaded gasoline plus 25 percent of the RVP of the intermediate gasoline plus 25 percent of the RVP of the premium unleaded gasoline. When the RVP for only one type of fuel was available, in addition to the RVP for regular unleaded gasoline, the weighted RVP was calculated as 75 percent of the RVP of the regular unleaded gasoline plus 25 percent of the RVP of either the intermediate or premium gasoline, whichever was available. When the RVP was available only for regular unleaded gasoline, the weighted RVP was the same as the RVP of the regular unleaded gasoline. This procedure was followed separately for each of the 23 cities from 1987 through 1991 for both January and July.

The second step was to assign a weighted January and July RVP for each year to every State. OMS provided a cross-reference listing of nonattainment areas throughout the United States with the corresponding MVMA survey city whose RVP should be used to represent that nonattainment area. These assignments were developed using pipeline distribution maps. The corresponding January and July weighted RVP values were then assigned to each of these nonattainment areas for all 5 years. The January or July RVP values for a given year for all nonattainment areas within a State were then averaged to estimate a single Statewide January or July RVP value for each year.

The next step was to estimate statewide RVP values for the remaining months, based on the January and July RVP values. The ASTM schedule of seasonal and geographical volatility classes was used as the basis for the RVP allocation by month (ASTM, 1988). This schedule assigns one or two volatility classes to each State for each month of the year. Volatility classes are designated by a letter from A through E, with A being the least volatile. Several States are divided into two or more regions, with each region having its own set of volatility class guidelines. The MOBILE4 user's guide provides guidance on which ASTM class to assign to each State for each month, when more than one region is included for a State, or when two ASTM classes are listed for a given State in a given month (EPA, 1989c). This guidance was followed here to select a single ASTM class for each State and each month. The MOBILE4 user's guide also lists RVP limits that correspond to each ASTM class from A through E (EPA, 1989c). These RVP limits, in pounds per square inch (psi), are as follows: ASTM class A = 9.0 psi; ASTM class B = 10.0 psi; ASTM class C = 11.5 psi; ASTM class D = 13.5 psi; ASTM class E = 15.0 psi. The January MVMA RVP for each State (determined in step 2 above) was assigned the January ASTM class, and the July MVMA RVP for each State was assigned the July ASTM class. Other months with the same ASTM class designation as either January or July were assigned the MVMA January or July RVP value. The RVP for months with intermediate ASTM class designations were calculated by interpolation using the January and July MVMA RVP values and the ASTM class RVP limits. The equation used for this interpolation is shown below.

$$IM = [(IA - SA) * (WM - SM) / (WA - SA)] + SM \tag{15}$$

where:

where:	IM	=	Intermediate month's (not January or July) MVMA RVP value
	IA	=	Intermediate month's (non-January or July) ASTM RVP limit
	SA	=	Summer (July) ASTM RVP limit
	WM	=	Winter (January) MVMA RVP value
	SM	=	Summer (July) MVMA RVP value
	WA	=	Winter (January) ASTM RVP limit

This was calculated for each intermediate month for each State for each of the 5 years.

The final step in determining seasonal RVP values was to average the monthly RVP values calculated in step 3. Winter RVP values were calculated by averaging the December, January, and February RVP values. Spring RVP was calculated as the average of the March, April, and May RVP values. Summer RVP was calculated as the average of the June, July, and August RVP values, and fall RVP was calculated as the average of September, October, and November RVP values. This was done separately for each year from 1987 through 1991 and for each State. Table IV.8 lists the 1990 seasonal RVP values calculated for each State.

b. Seasonal Temperatures

Average seasonal maximum and minimum temperatures for each State were developed for use as inputs to MOBILE4.1. State normal daily maximum and minimum temperatures for each month were obtained from National Oceanic and Atmospheric Administration (NOAA) documents (NOAA, 1982). The NOAA temperatures were averages based on the 30-year period from 1951 to 1980. Each State's average seasonal maximum and minimum temperatures were calculated by taking the average of the

Table IV.8

1990 Seasonal RVP (psi) by State

State	Winter	Spring	Summer	Fall
AL	12.8	10.3	9.1	9.7
AZ	10.1	8.5	8.1	8.3
AR	13.4	10.7	8.7	10.9
CA	12.3	10.1	8.1	8.7
CO	11.5	9.6	8.5	9.3
CT	13.2	10.2	8.3	10.2
DE	13.9	10.5	8.4	9.4
DC	12.2	9.1	8.2	9.1
FL	11.9	9.1	9.1	9.1
GA	12.5	10.2	9.1	9.6
ID	12.5	10.5	9.1	9.5
IL	13.7	10.5	8.6	9.6
IN	13.8	10.6	8.7	9.7
IA	13.4	11.2	10.0	11.2
KS	12.5	9.5	8.5	9.0
KY	12.9	9.6	8.7	9.6
LA	12.2	10.0	8.9	9.4
ME	13.1	10.1	8.3	10.1
MD	13.4	10.2	8.3	9.3
MA	13.1	10.1	8.3	10.1
MI	13.8	10.9	9.1	10.9
MN	13.4	11.0	9.6	10.3
MS	13.4	10.7	9.4	10.0
MO	12.4	10.7	8.6	10.2
MT	13.1	10.1	8.6	10.1
NE	13.0	10.5	9.1	9.5
NV	10.9	8.8	8.2	8.5
NH	13.1	10.1	8.3	10.1
NJ	13.8	10.5	8.4	10.5
NM	11.6	9.0	8.1	9.3
NY	13.4	10.2	8.3	10.2
NC	12.5	11.0	9.1	10.4
ND	13.4	11.8	9.6	10.9
OH	13.9	11.2	9.6	10.4
OK	13.1	9.6	8.2	8.9
OR	12.4	10.4	8.8	9.6
PA	13.9	10.6	8.6	10.6
RI	13.1	10.1	8.3	10.1
SC	12.5	11.0	9.1	10.4
SD	13.0	10.9	9.6	10.0
TN	12.7	11.1	9.1	10.5
TX	12.4	9.9	8.0	8.6
UT	11.5	10.0	8.5	9.3
VT	13.1	10.1	8.3	10.1
VA	12.1	9.1	8.2	9.1
WA	13.6	11.1	9.6	10.4
WV	13.5	10.8	9.1	9.9
WI	13.7	10.7	8.8	9.7
WY	12.2	9.8	8.4	8.8

NOTES: Based on RVPs from the January and July MVMA Fuel Volatility Surveys interpolated to Spring and Fall.

monthly maximum and minimum temperatures. Winter temperatures were calculated by averaging December, January, and February temperatures. Spring temperatures were calculated by averaging March, April, and May temperatures. Summer temperatures were calculated by averaging June, July, and August temperatures. Fall temperatures were calculated by taking the average of September, October, and November temperatures. Table IV.9 lists the seasonal temperatures used as MOBILE4.1 inputs for each State.

2. *Seasonal Allocation of VMT*

Motor vehicle travel activity is not constant throughout the year. In order to best estimate motor vehicle emissions, the annual VMT estimates calculated for the Interim Inventory were allocated to seasons using the NAPAP temporal allocation factors (EPA, 1990). The NAPAP temporal allocation factors for motor vehicles did not vary by State. The allocation factors used for each motor vehicle source category are listed in Table IV.10. Generally speaking, for vehicle type other than trucks, travel activity is highest in the summer months.

3. *Emission Summary*

An emission summary for the motor vehicle inventories is provided in Table IV.11.

Motor vehicle VOC emissions are normally highest during the ozone season (summer) due to increased temperatures and travel activity. Figure IV.1 compares average annual daily motor vehicle emissions with average ozone season daily motor vehicle emissions for 1990. Figure IV.1 shows only a slight increase in average daily motor vehicle VOC emissions during the ozone season. The small increase in average daily ozone season VOC emissions reflects the dramatic difference between summer and winter gasoline RVPs in 1990. The lower RVP of gasoline used during the summer months has decreased evaporative VOC emissions considerably from previous years. Exhaust VOC emissions are highest at low temperatures.

Table IV.9

Seasonal Maximum and Minimum Temperatures (°F) by State

State	Winter Min	Winter Max	Spring Min	Spring Max	Summer Min	Summer Max	Fall Min	Fall Max
AL	42	62	57	78	72	91	58	79
AK	20	31	32	46	46	63	36	47
AZ	41	67	54	83	76	103	59	86
AR	32	53	50	73	70	92	51	75
CA	45	61	50	67	59	78	54	73
CO	18	45	34	61	56	85	37	66
CT	19	36	38	59	60	83	42	63
DE	25	42	42	62	64	84	47	66
DC	29	45	47	66	68	86	51	69
FL	52	72	62	77	73	89	65	82
GA	34	54	50	72	68	87	52	73
HI	66	81	69	83	73	87	71	86
ID	25	40	37	61	56	86	39	64
IL	17	33	39	59	62	83	43	63
IN	21	37	41	62	63	84	44	65
IA	15	31	39	59	64	84	42	63
KS	23	44	44	67	68	91	47	69
KY	27	44	45	66	66	86	47	68
LA	44	64	59	78	73	90	60	79
ME	14	33	33	52	55	76	38	59
MD	26	43	43	64	65	85	47	68
MA	25	38	41	56	63	79	48	62
MI	14	30	33	53	55	77	39	57
MN	5	24	32	51	56	78	36	54
MS	36	59	53	77	70	92	53	78
MO	22	40	44	65	66	87	52	67
MT	14	33	31	54	52	80	35	58
NE	15	35	40	62	64	86	42	65
NV	21	47	31	64	45	87	31	69
NH	12	33	32	56	54	80	36	60
NJ	25	43	41	61	62	82	46	66
NM	24	49	40	70	62	91	43	71
NY	21	36	39	57	61	81	45	62
NC	32	54	48	72	67	88	51	73
ND	1	23	30	53	54	82	31	57
OH	22	38	40	61	61	82	44	64
OK	28	50	48	71	69	91	50	73
OR	35	47	42	61	55	77	45	64
PA	24	39	41	61	62	83	45	65
RI	22	38	38	57	61	80	44	63
SC	34	58	51	76	69	91	52	76
SD	7	27	34	56	59	84	36	60
TN	31	50	50	71	69	89	51	73
TX	37	61	54	78	71	95	55	79
UT	22	40	37	62	58	89	40	66
VT	11	28	33	52	56	78	39	57
VA	31	49	47	68	67	86	51	71
WA	30	42	39	57	53	76	41	59
WV	26	44	43	66	62	84	45	67
WI	15	29	35	53	59	78	41	59
WY	17	40	30	54	52	80	34	60

SOURCE: NOAA, 1982.

Table IV.10

Temporal Allocation Factors by Vehicle Type

Vehicle Type	Winter	Spring	Summer	Fall
LDGV				
Rural	0.216	0.239	0.289	0.256
Urban	0.234	0.255	0.265	0.245
LDGT				
Rural	0.216	0.239	0.289	0.256
Urban	0.234	0.255	0.265	0.245
HDGV				
Rural and Urban	0.250	0.250	0.250	0.250
LDDV				
Rural	0.216	0.239	0.289	0.256
Urban	0.234	0.255	0.265	0.245
LDDT				
Rural	0.216	0.239	0.289	0.256
Urban	0.234	0.255	0.265	0.245
HDDV				
Rural and Urban	0.250	0.250	0.250	0.250

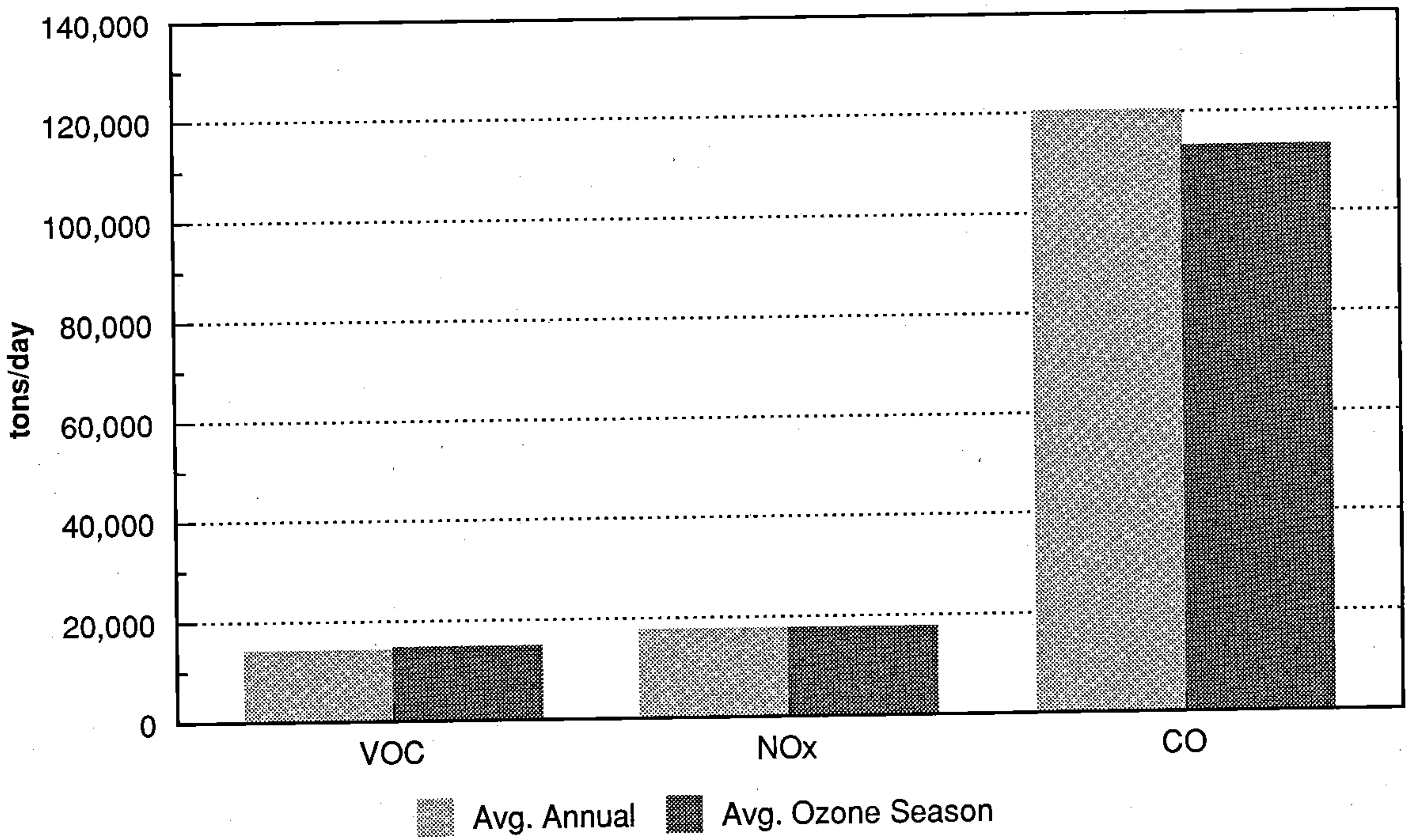
SOURCE: EPA, 1990.

Table IV.11

Summary of Motor Vehicle Emissions (thousand tons per year)

Pollutant	1987	1988	1989	1990	1991
VOC	6,753	6,478	5,342	5,075	4,753
NO_x	7,043	6,891	6,504	6,411	6,017
CO	53,716	51,404	45,714	43,719	40,562
SO_2	540	569	580	611	634

Figure IV.1
Average Annual Daily Emissions vs. Average Ozone Season Daily Emissions for Motor Vehicles



CHAPTER V
AREA SOURCE SOLVENT EMISSIONS

Solvent emissions are included as both point and area sources in the Interim Inventories. Point source emissions (included in the non-utility point source inventory) are based on the 1985 NAPAP Emission Inventory. The basis for the area source component (the solvent inventory) is a material balance on total nationwide solvent consumption. Total nationwide solvent emissions by end-use category are estimated from national consumption figures with some adjustments to account for air pollution controls and waste management practices. The nationwide emission estimates are then apportioned to States and counties using census data and information on State and local regulations pertaining to solvent emissions. At this stage, county- and category-level point source emissions are deducted from the emission totals, and the balance of emissions is included in the area source solvent inventory. The following sections describe the development of national solvent emission estimates, apportionment to States and counties, and short-term projections to the timeframes covered by the Interim Inventory.

A. OVERALL NATIONAL EMISSIONS ESTIMATES

The overall national solvents material balance can be summarized as follows:

$$\begin{array}{c}\text{National solvent}\\\text{emissions (by end-}\\\text{use category)}\end{array} = \begin{array}{c}\text{National solvent}\\\text{consumption}\end{array} - \begin{array}{c}\text{Solvents}\\\text{destroyed by air}\\\text{pollution}\\\text{controls}\end{array} - \begin{array}{c}\text{Solvents conveyed}\\\text{to waste}\\\text{management}\\\text{operations}\end{array} \quad (1)$$

(It should be noted that this overall national material balance yields total solvent emissions, including both point and area sources.)

National solvent usage estimates by end-use category were obtained from three main sources. For paints and coatings, the main source was the U.S. Paint Industry Data Base, prepared by SRI International for the National Paint and Coatings Association (Connolly et al., 1990). Solvent usage estimates for other categories were obtained from industrial solvent marketing reports (Frost & Sullivan, 1989; Freedonia, 1989). The base year for this activity data and for the total solvent emission estimates is 1989.

The solvent emission methodology is designed to incorporate pollution control and waste management information at the source category level. However, the timeframe of the current effort was too tight to permit development of category-specific information. The mass balance term for waste management was based on the EPA's data base for hazardous waste treatment, storage, and disposal facilities (TSDF), which also forms the basis for the TSDF portion of the Interim Inventory (EPA, 1989d). In essence, the portion of the TSDF inventory that is attributable to solvents is deducted from the current solvents inventory in order to avoid double-counting. The TSDF deduction was apportioned evenly to all industrial categories, and amounts to about 21 percent of total solvent usage in these categories.

Solvent destruction adjustments in the nationwide material balance were based on the same assumptions used for the 1985 National Emissions Data System (NEDS) and the 1985 NAPAP Emissions Inventories. According to the data in NEDS and NAPAP, 16 percent of industrial surface coating emissions are assumed to be destroyed in air pollution controls.

Table V.1 lists the elements in the national solvent material balance by emission source category. As discussed above, these elements are: national solvent consumption, solvent destroyed in air pollution controls, solvent sent to waste management operations, and net solvent emissions. Table V.1 also summarizes the major sources of these data.

B. DISTRIBUTION OF SOLVENT EMISSIONS TO STATES AND COUNTIES

The primary tools used to distribute national solvent emissions to States and counties are 1988 census data bases (BOC, 1987; BOC, 1988a; BOC, 1988b). For each of the source categories listed in Table V.1, State- and county-level solvent usage is assumed to be proportional to a particular census measure. For consumer end-use categories, solvent usage was distributed based on population. County-level employment data were used for commercial and industrial end-use categories. Census data on the number of farm acres treated with chemical sprays were used to distribute pesticide solvent usage. Table V.2 lists the specific census data used for each emission category.

State and local regulations covering solvent emissions were also incorporated in the spatial distribution step for the solvent inventories. For an industrial or commercial end-use category, the overall spatial distribution calculation can be summarized as follows:

$$\begin{array}{c}\text{County}\\ \text{emissions (by}\\ \text{end-use category)}\end{array} = \begin{array}{c}\text{National}\\ \text{emissions}\end{array} * \frac{\text{County employment}}{\text{National employment}} * \frac{\text{Estimated control efficiency for county}}{\text{Nationwide average control efficiency for category}} \qquad (2)$$

Quantitative information on State- and county-level control efficiency, rule effectiveness, and rule penetration was obtained primarily from surveys carried out under EPA's ongoing ROM modeling effort (EPA, 1991e). For States outside the ROM domain, these parameters were estimated using Bureau of National Affairs regulation summaries.

Table V.1

National Material Balance for Solvent Emissions

Category	Description	Solvent Usage (1,000 tpy)	Percent Destroyed by Air Pollution Controls[1]	Percent Sent to TSDFs[2]	Estimated Emissions (1,000 tpy)	Source
Surface Coating						
2401001	Architectural	503	0	0	503	SRI International/
2401005	Auto refinishing	133	0	0	133	National Paint and
2401008	Traffic markings	106	0	0	106	Coatings Institute
2401015	Flat wood coating	5	16	21	3	
2401020	Wood furniture	221	16	21	139	
2401025	Metal furniture	70	16	21	44	
2401030	Paper coating	33	16	21	21	
2401040	Can coating	156	16	21	99	
2401045	Coil coating	58	16	21	37	
2401055	Electrical insulation	48	16	21	30	
2401060	Appliances	34	16	21	21	
2401065	Machinery	130	16	21	82	
2401070	Motor vehicles (new)	134	16	21	85	
2401075	Aircraft coating	11	16	21	7	
2401080	Marine paints	29	16	21	18	
2401085	Rail equip. coating	6	16	21	4	
2401090	Misc. manufacturing	210	16	21	132	
2401100	Industrial maintenance	99	0	21	78	
2401200	Aerosols, spec. purpose	173	0	21	137	
Vapor Degreasing (Conveyorized and Open-Top)						
2415105	Furniture	9	0	21	7	Total category
2415110	Metallurgical proc.	29	0	21	23	number from Frost
2415120	Fabricated metals	97	0	21	76	& Sullivan.
2415125	Industrial machinery	100	0	21	79	Industry
2415130	Electrical equipment	98	0	21	77	breakdowns from
2415135	Transportation equip.	36	0	21	28	EPA BDAT Report
2415140	Instrument mfg.	48	0	21	38	for spent solvents.
2415145	Misc. manufacturing	17	0	21	13	
Cold Cleaner Degreasing						
2415305	Furniture	12	0	21	9	Total category
2415310	Metallurgical proc.	8	0	21	7	number from Frost
2415320	Fabricated metals	38	0	21	30	& Sullivan.
2415325	Industrial machinery	52	0	21	41	Industry
2415330	Electrical equipment	16	0	21	12	breakdowns from
2415335	Transportation equip.	12	0	21	9	EPA BDAT Report
2415340	Instruments	8	0	21	6	for spent solvents.
2415345	Misc. manufacturing	19	0	21	15	
2415355	Automobile dealers	191	0	21	151	
2415360	Automobile repair	70	0	21	55	
2415365	Other	5	0	21	4	
Other Categories						
2420010	Drycleaning (perc.)	135	0	21	107	Frost & Sullivan
2420010	Drycleaning (petroleum)	134	0	21	105	Frost & Sullivan
2420020	Coin-op drycleaning	2	0	21	1	Frost & Sullivan
2425000	Graphic arts	276	16	21	174	Frost & Sullivan
2430000	Rubber/plastics	48	16	21	30	Frost & Sullivan
2440020	Adhesives - industrial	460	0	21	363	Freedonia Group
2461021	Cutback asphalt	200	0	0	200	Asphalt Institute
2461800	Pesticides - farm	260	0	0	260	Freedonia Group
2465100	Personal products	228	0	0	228	Frost & Sullivan
2465200	Household products	186	0	0	186	Frost & Sullivan
2465400	Automotive products	650	0	0	650	Freedonia Group
2465600	Adhesives - Comml.	350	0	0	350	Frost & Sullivan

NOTES: [1]Based on the 1985 NEDS methodology. Does not include solvents that are captured and recycled.
[2]Calculated based on the TSDF sector of the 1985 NAPAP Inventory.

Table V.2

Data Bases Used for County Allocation

AMS Category	Description	Allocation Data (from the Census)
Surface Coating		
2401001	Architectural	Population
2401005	Auto refinishing	Employment in SIC 7532
2401008	Traffic markings	Population
2401015	Flat wood coating	Employment in SIC 2430
2401020	Wood furniture	Employment in SIC 25
2401025	Metal furniture	Employment in SIC 25
2401030	Paper coating	Employment in SIC 26
2401040	Can coating	Employment in SIC 341
2401045	Coil coating	Employment in SIC 344
2401055	Electrical insulation	Employment in SIC 36
2401060	Appliances	Employment in SIC 363
2401065	Machinery	Employment in SIC 35
2401070	Motor vehicles (new)	Employment in SIC 371
2401075	Aircraft coating	Employment in SIC 372
2401080	Marine paints	Employment in SIC 373
2401085	Rail equip. coating	Employment in SIC 374
2401090	Misc. manufacturing	Employment in SIC 20-39
2401100	Industrial maintenance	Employment in SIC 20-39
2401200	Aerosols, spec. purpose	Population
Vapor Degreasing (Conveyorized and Open-Top)		
2415105	Furniture	Employment in SIC 25
2415110	Metallurgical proc.	Employment in SIC 33
2415120	Fabricated metals	Employment in SIC 34
2415125	Industrial machinery	Employment in SIC 35
2415130	Electrical equipment	Employment in SIC 36
2415135	Transportation equip.	Employment in SIC 37
2415140	Instrument mfg.	Employment in SIC 38
2415145	Misc. manufacturing	Employment in SIC 39
Cold Cleaner Degreasing		
2415305	Furniture	Employment in SIC 25
2415310	Metallurgical proc.	Employment in SIC 33
2415320	Fabricated metals	Employment in SIC 34
2415325	Industrial machinery	Employment in SIC 35
2415330	Electrical equipment	Employment in SIC 36
2415335	Transportation equip.	Employment in SIC 37
2415340	Instruments	Employment in SIC 38
2415345	Misc. manufacturing	Employment in SIC 39
2415355	Automobile dealers	Employment in SIC 55
2415360	Automobile repair	Employment in SIC 75
2415365	Other	Employment in SIC 22
Other Categories		
2420010	Drycleaning (perc.)	Employment in SIC 7216
2420010	Drycleaning (petroleum)	Employment in SIC 7216
2420020	Coin-op drycleaning	Employment in SIC 7215
2425000	Graphic arts	Employment in SIC 27
2430000	Rubber/plastics	Employment in SIC 30
2440020	Adhesives - industrial	Employment in SIC 20-39
2461021	Cutback asphalt	Population
2461800	Pesticides - farm	Farm acres treated with sprays
2465100	Personal products	Population
2465200	Household products	Population
2465400	Automotive products	Population
2465600	Adhesives - Comml.	Population

C. DEDUCTION OF POINT SOURCE EMISSIONS

The area source inventory is produced by deducting point source emissions from the county-level category emission totals produced in equation 2. The calculation is performed as follows:

$$\text{County-level area source emissions (by end-use category)} = \text{Total county-level emissions (equation 2)} - \text{County-level point source emissions} \quad (3)$$

The AMS solvent categories were first matched to the corresponding point source SCCs. Using the Interim 1990 Point Source Inventory, point source totals by county for each corresponding AMS SCC were calculated. These emissions were then subtracted from the total solvent emissions (the 1989 total solvent emissions were projected to 1990 as described below) to yield the area source emission estimate. In the cases of negative emissions (higher point source emission estimates than total estimated solvent emissions), the NAPAP methodology (EPA, 1988) was followed -- area source emissions were set to zero.

D. PROJECTING SOLVENT EMISSIONS TO OTHER INVENTORY YEARS

The Interim Inventories give annual area source solvent emissions for 5 calendar years (from 1987 through 1991). The total solvent inventory was based on 1989 activity-level data. (Spatial allocations for the solvent area source inventory were based on the 1988 census, which provides the most recent data available at the county level.) Projections to other years covered by the Interim Inventory are based on State-level earnings data for major industrial categories, which generally correspond to 2-digit SICs. A description of the BEA data can be found in Chapter III. The following algorithm is used for the emission projection:

$$\text{Projection year emissions (by county and end-use category)} = \text{Base year emissions} * \frac{\text{Projection year earnings (by State and 2-digit SIC)}}{\text{Base year earnings}} \quad (4)$$

In this equation, the projection year represents the appropriate calendar year for the Interim Inventory (ranging from 1987 to 1991). The total solvent inventory was first projected to 1990 to complete the point source deduction described above. After deducting the point source solvents, this 1990 area source solvent data base was then scaled-back/projected to the other inventory years.

The county/source category emissions predicted using changes in BEA earnings data were then scaled according to expected changes in national solvent emissions. Annual changes in national solvent usage (by end-use category) were taken from the solvent marketing reports (Frost & Sullivan, 1989; Freedonia, 1989). All county-level emissions within an end-use category were scaled by a factor so that total national emissions would be equivalent to the national solvent emission estimates reported in the literature.

E. EMISSION SUMMARY

A summary of solvent emissions by source category is given in Table V.3.

Table V.3

Solvent Inventory Emission Summary

Source Category	Annual VOC Emissions (1,000 tpy) 1987	1988	1989	1990	1991
Surface Coating	1,563	1,567	1,554	1,540	1,532
Degreasing	611	680	682	684	685
Drycleaning	215	214	211	208	204
Graphic Arts	126	137	136	135	135
Rubber/Plastics	29	29	29	28	28
Misc. Industrial	339	353	361	370	378
Misc. Non-Industrial: Commercial	448	460	458	456	454
Misc. Non-industrial: Consumer	1,319	1,374	1,409	1,444	1,480
Total	**4,650**	**4,815**	**4,839**	**4,864**	**4,896**

CHAPTER VI
AREA SOURCE EMISSIONS

The basis for the emission estimates for area source (non-solvent) categories is the 1985 NAPAP Area Source Emissions Inventory (EPA, 1989a). This chapter discusses area source emission estimates performed for this study other than those for highway vehicles and solvent use. The methodology used to estimate emissions for the inventory years including the sources for growth indicators, revisions to emission estimates, updated emission factors, and control efficiency assumptions are discussed.

A. GROWTH INDICATORS

Emission estimates from the 1985 NAPAP Inventory were grown to the Interim Inventory years based on historical BEA earnings data (see Chapter III), historical estimates of fuel consumption (DOE, 1991a), or other category-specific growth indicators. Table VI.1 shows the growth indicators used for each NAPAP area source category.

The SEDS data (DOE, 1991a) were used as an indicator of emissions growth for the area source fuel combustion categories and for the gasoline marketing categories shown in Table VI.1. (SEDS reports fuel consumption by sector and fuel type.) Since fuel consumption is the activity level used to estimate emissions for these categories, fuel consumption is a more accurate predictor of changes in emissions, compared to other surrogate indicators such as earnings or population. SEDS fuel consumption data were available through 1989. The 1990 and 1991 values were extrapolated from the 1985 through 1989 data using a log linear regression technique. In addition to projecting 1990 and 1991 data for all fuel consumption categories, the regression procedure was used to fill in missing data points for fuel consumption categories if at least three data points in the time series (1985 to 1989) were available.

Due to the year-to-year volatility in the SEDS fuel consumption data for the commercial residual oil fuel use category, the regression technique used above did not yield realistic projections for 1990 and 1991 for this category. Therefore, a different procedure was used to project 1990 and 1991 data for commercial residual oil fuel use. State-level sales volumes of residual fuel to the commercial sector were obtained from *Fuel Oil and Kerosene Sales 1990* (DOE, 1991b) for 1989 and 1990. Each State's growth in sales of residual fuel to the commercial sector from 1989 to 1990 was applied to that State's 1989 SEDS commercial residual fuel consumption to yield a 1990 consumption estimate. Sales data for 1991 were not yet available; the growth decline from 1990 to 1991 was assumed to be the same as from 1989 to 1990. A summary of SEDS national fuel consumption by fuel and sector can be found in Table VI.2.

Table VI.1

Area Source Growth Indicators

NAPAP SCC	Category Description	Data Source	Growth Indicator
1	Residential Fuel - Anthracite Coal	SEDS	Res - Anthracite
2	Residential Fuel - Bituminous Coal	SEDS	Res - Bituminous
3	Residential Fuel - Distillate Oil	SEDS	Res - Distillate oil
4	Residential Fuel - Residual Oil		Zero growth
5	Residential Fuel - Natural Gas	SEDS	Res - Natural gas
6	Residential Fuel - Wood	BEA	Population
7	Commercial/Institutional Fuel - Anthracite Coal	SEDS	Comm - Anthracite
8	Commercial/Institutional Fuel - Bituminous Coal	SEDS	Comm - Bituminous
9	Commercial/Institutional - Distillate Oil	SEDS	Comm - Distillate oil
10	Commercial/Institutional - Residual Oil	SEDS	Comm - Residual oil
11	Commercial/Institutional - Natural Gas	SEDS	Comm - Natural gas
12	Commercial/Institutional - Wood	BEA	Services
13	Industrial Fuel - Anthracite Coal	SEDS	Ind - Anthracite
14	Industrial Fuel - Bituminous Coal	SEDS	Ind - Bituminous
15	Industrial Fuel - Coke	BEA	Total Manufacturing
16	Industrial Fuel - Distillate Oil	SEDS	Ind - Distillate oil
17	Industrial Fuel - Residual Oil	SEDS	Ind - Residual oil
18	Industrial Fuel - Natural Gas	SEDS	Ind - Natural gas
19	Industrial Fuel - Wood	BEA	Total Manufacturing
20	Industrial Fuel - Process Gas	SEDS	Ind - LPG
21	On-Site Incineration - Residential	BEA	Population
22	On-Site Incineration - Industrial	BEA	Total Manufacturing
23	On-Site Incineration-Commercial/Institutional	BEA	Services
24	Open Burning - Residential	BEA	Population
25	Open Burning - Industrial	BEA	Total Manufacturing
26	Open Burning - Commercial/Institutional	BEA	Services
39	Off-Highway Gasoline Vehicles	BEA	Population
44	Off-Highway Diesel Vehicles	BEA	Construction + Farm
45	Railroad Locomotives	AAR, 1991	Railroad ton-miles (national)
46	Aircraft LTOs - Military	BEA	Military
47	Aircraft LTOs - Civil	FAA, 1991b	Aircraft - civil
48	Aircraft LTOs - Commercial	FAA, 1991a	Aircraft - commercial
49	Vessels - Coal	Corp of Engineers, 1991	Cargo tonnage (national)
50	Vessels - Diesel Oil		Cargo tonnage (national)
51	Vessels - Residual Oil		Cargo tonnage (national)
52	Vessels - Gasoline	BEA	Population
54	Gasoline Marketed	SEDS	Trans - Motor gasoline
60	Forest Wild Fires		Zero growth
61	Managed Burning - Prescribed		Zero growth

Table VI.1 (continued)

NAPAP SCC	Category Description	Data Source	Growth Indicator
62	Agricultural Field Burning	BEA	Farm
63	Frost Control - Orchard Heaters	BEA	Farm
64	Structural Fires		Zero growth
99	Minor Point Sources	BEA	Population
100	Publicly Owned Treatment Works	BEA	Electric, Gas, and Sanitary Services
102	Fugitive Emissions From Synthetic Organic Chemical Manufacturing	BEA	Mfg - Chemicals and Allied Products
103	Bulk Terminal and Bulk Plants	BEA	Trucking and Warehousing
104	Fugitive Emissions From Petroleum Refinery		Refinery operating cap
105	Process Emissions From Bakeries	BEA	Mfg - Food and Kindred Products
106	Process Emissions From Pharmaceutical Manufacturing	BEA	Mfg - Chemicals and Allied Products
107	Process Emissions From Synthetic Fiber Manufacturing	BEA	Mfg - Textile Mill Products
108	Crude Oil and Natural Gas Production Fields	BEA	Oil and Gas Extraction
109	Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDFs)	BEA	Total Manufacturing

Table VI.2

SEDS National Fuel Consumption

Category	1985	1986	1987	1988	1989	1990	1991
Anthracite Coal (thousand short tons)							
Commercial	524	494	478	430	422	410	403
Industrial	575	470	437	434	392	387	385
Residential	786	740	717	646	633	615	604
Bituminous Coal (thousand short tons)							
Commercial	4,205	4,182	3,717	3,935	3,323	3,470	3,515
Industrial	115,854	111,119	111,695	117,729	117,112	118,322	120,414
Residential	2,264	2,252	2,002	2,119	1,789	1,869	1,893
Distillate Fuel (thousand barrels)							
Commercial	107,233	102,246	101,891	98,479	91,891	95,385	96,712
Industrial	203,659	206,108	210,699	209,553	197,035	205,856	208,503
Residential	171,339	173,736	176,822	182,475	178,629	184,501	187,994
Liquefied Petroleum Gases (thousand barrels)							
Industrial	437,964	411,451	447,120	453,599	441,784	457,013	473,897
Motor Gasoline (thousand barrels)							
Transportation	2,433,592	2,507,936	2,570,047	2,627,331	2,617,450	2,703,666	2,758,444
All Sectors	2,493,361	2,567,436	2,630,089	2,685,145	2,674,669	2,760,414	2,814,398
Natural Gas (million cubic feet)							
Commercial	2,432	2,318	2,430	2,670	2,719	2,810	2,928
Industrial	6,867	6,502	7,103	7,479	7,887	8,120	8,495
Residential	4,433	4,314	4,315	4,630	4,777	4,805	4,922
Residual Fuel (thousand barrels)							
Commercial	30,956	39,480	41,667	42,256	35,406	27,776	28,216
Industrial	120,002	132,249	107,116	105,448	95,646	118,122	158,077

Additional data were gathered for several categories for use in the emission projections. Growth indicators other than BEA or SEDS data were developed for petroleum refinery fugitives and several off-road vehicle source categories, including aircraft (commercial and civil), railroads, and marine vessels (other than gasoline-powered).

Activity levels for aircraft are measured by the number of landing-takeoff operations (LTOs). Annual LTO totals are compiled by the Federal Aviation Administration (FAA) on a regional basis. Commercial aircraft growth is derived from the summation of air carrier and air taxi regional totals of LTOs from FAA-operated control towers and FAA traffic control centers (FAA, 1991a). These data are compiled on a regional basis, so the regional trends were applied to each State. Civil aircraft growth indicators were also developed from regional LTO totals. Civil aircraft activity levels were determined from terminal area activity for the years 1985 through 1989, and from a 1990 forecast of terminal area activity (FAA, 1991b). Military aircraft LTO totals were not available; consequently, BEA data were used.

Railroad data are provided by the Association of American Railroads (AAR). National totals of revenue-ton-miles for the years 1985 through 1990 are used to estimate changes in activity during this period. The national growth is therefore applied to each State and county (AAR, 1991).

Marine vessel activity is recorded annually by the U.S. Army Corp of Engineers. Cargo tonnage national totals are used to determine growth in diesel- and residual-fueled vessel use through the year 1989 (Corp of Engineers, 1991). Gasoline-powered vessels are used predominantly for recreation, so growth for this category is therefore based on population.

Petroleum refinery fugitive emissions were grown to the inventory years based on refinery capacity by State, as reported in DOE's Petroleum Supply Annuals for 1985 through 1990 (DOE, 1991c). State capacity for 1991 was extrapolated based on the data for the previous years.

B. REVISED EMISSION ESTIMATES

Hazardous waste TSDF emissions were updated using a file from EPA's Emission Standards Division (ESD), created in April 1989 (EPA, 1989d). This file provided estimates of TSDF emissions with longitude and latitude as the geographical indicator for each facility. The longitude and latitude were used to match each emission estimate to the appropriate State and county.

Area source petroleum refinery fugitive emissions were re-estimated based on a revised estimate of national petroleum refinery emissions. The national petroleum refinery emissions used to estimate area source emission in the 1985 NAPAP is from *Trends* (EPA, 1986). The emission estimate for blowdown systems was revised to reflect the high level of control as shown in the point source inventory. Appendix B is a comparison of *Trends* and NAPAP emissions and outlines the reasons for revising the blowdown emission estimate.

The area source petroleum refinery fugitive emissions were re-estimated using the revised national emission total by applying the methodology used to develop the 1985 NAPAP estimate (EPA, 1988). Total county fugitive petroleum refinery emissions were determined by distributing the revised *Trends* estimate (excluding process heaters and catalytic cracking units) based on 1985 county refinery capacity from the DOE Petroleum Supply Annual (DOE, 1986). Refinery capacity from this publication was allocated to counties based on the designated location of the refinery. NAPAP was used to aid in the matching of refineries to location.

Total area source petroleum refinery fugitive emissions were then estimated by subtracting the point source emissions (SCCs 3-06-004 through 3-06-888) from the total county-level emissions. Negative values (indicating higher point source emissions than the totals shown for the county), were re-allocated to counties exhibiting positive emission values based on the proportion of total refinery capacity for each county to avoid double-counting of emissions. This resulted in an emission estimate of 351 thousand tons for 1985 compared with the prior NAPAP estimate of 728 thousand tons (area source refinery fugitives). This revised 1985 estimate was grown to the inventory years, as described above.

A review of the 1985 NAPAP industrial natural gas combustion NO_x emission estimate was also completed for this study. Appendix C presents the results of this analysis. Due to the time constraints of this analysis, no changes were made to the emission estimate for this source category. The findings in Appendix C indicate that further investigation of this category is needed.

C. EMISSION FACTOR CHANGES

Emission factors for several sources were updated to reflect recent technical improvements in AP-42 and other emission inventory guidance documents. Emission factors for all four pollutants were updated for railroads and residential wood combustion. SO_2 emission factors for aircraft were also updated.

Railroad emission factors in NAPAP were derived from data in AP-42. Improved emission factors for railroad locomotives have recently been developed in a revision to EPA's mobile source emission inventory guidance (EPA, 1991f). These updated emission factors were incorporated into the Interim Inventory emission estimates. Railroad emission factors are summarized in Table VI.3 for line-haul locomotives and yard (switch) locomotives. Because only one set of emission factors is required for railroads, the separate emission factors for line-haul and yard locomotives were weighted by fuel usage. AAR provided data on fuel consumption by line-haul and yard locomotives for Class I railroads for 1985 through 1990, as shown in Table VI.4.

AP-42 sections for residential wood combustion sources have recently been updated. With the exception of the SO_2 emission factor (which has not changed), emission factors for each pollutant have decreased. Table VI.5 lists the NAPAP emission factors (which reflect a combination of wood-burning devices) and the emission factors listed in the revised AP-42 sections. No data are available to weight these emission factors. Because of this, and because conventional woodstoves constitute the majority of woodstoves nationwide, these data were used to calculate *all* residential wood combustion emissions.

Table VI.3

Railroad Locomotives
Diesel Fuel Consumption
1985 to 1990
(million gallons)

Year	Line-Haul	Switch
1985	2,889	255
1990	2,876	258

SOURCE: AAR, 1991.

Table VI.4

Railroad Emission Factors (lb/1,000 gallons)

	Wtg. Factor	NO_x	CO	HC	SO_2
NAPAP		370	130	90	57
Revised*					
Line-haul	2,876	493.1	62.6	20.1	36.0
Yard	258	504.4	89.4	48.2	36.0
New Wtd. Avg.		494	65	22	36

SOURCE: *EPA, 1991f.

Table VI.5

Residential Wood Combustion Emission Factors

	Emission Factors (lb/ton)			
	VOC	CO	NO_x	SO_x
1985 NAPAP	85.72	242.63	2.92	0.40
Conventional Stoves	28.00	230.80	2.80	0.40
Noncatalytic Stoves	ND	140.80	ND	0.40
Pellet Stoves*	ND	39.40	13.80	0.40
Catalytic Stoves	17.20	104.80	2.00	0.40
Fireplaces	26.00	122.20	1.80	0.40

NOTES: ND = no data
* Pellet stoves comprise less than 2 percent of the national population.

Because conventional stove emissions are higher than other wood-burning devices, this will provide an upper bound of emissions.

Review of emission factors for other area sources show that emission factors for several off-road categories have been revised in recent technical reports. Aircraft and off-road vehicles and engines have both undergone significant revision or improvement. Due to the complexity of the emission factor derivation process for these categories (weighting by different engine types), however, it is difficult to develop an improved set of emission factors under the time constraints of this study. Because of this, and because much of the emission factor data has *not* changed, the emission factors presented in NAPAP will continue to be used in the Interim Inventories.

The SO_2 emission rate from aircraft is one exception to this case. AP-42 emission rates were compared with emission rates published in EPA's emission inventory guidance (EPA, 1991g). SO_2 rates were an average of 54 percent lower, due to changes in fuel sulfur content. This change was incorporated into the aircraft emission estimates for the Interim Inventories. (Although new data were available only for civil aircraft, the emission factor change was incorporated for all aircraft). Aircraft emission factors for VOC, NO_x, and CO have not changed. Table VI.6 is a comparison of SO_2 emission rates from aircraft.

D. CONTROL EFFICIENCY ASSUMPTIONS

Control efficiencies (and an 80 percent rule effectiveness) were incorporated in the data files for VOC emissions from gasoline marketing (Stage I and vehicle refueling), petroleum refinery fugitives, and bulk gasoline plants and terminals.

The NAPAP gasoline marketing service station emission estimate was broken into two components -- evaporative losses from underground tanks (Stage I) and Stage II vehicle refueling (including spillage). The NAPAP emission estimate was derived based on gasoline usage combined with the uncontrolled emission factors from AP-42. These emission factors are as follows:

Stage I:	7.3 lbs/1,000 gallons
Stage II:	11.0 lbs/1,000 gallons
Spillage:	0.7 lbs/1,000 gallons

These emission factors were used to calculate the fraction of total emissions attributable to each of the components above. The total percentage is 38.4 percent for Stage I emissions and 61.6 percent for Stage II emissions, plus spillage.

Many areas already have regulations in place for controlling Stage I and Stage II gasoline marketing emissions. Many current State regulations require the use of Stage I controls (except at small volume service stations) to reduce emissions by 95 percent. Emission estimates were revised to reflect these controls in areas designated as having these requirements as part of their SIPs (Battye, 1987). Stage II vapor recovery systems are estimated to reduce emissions by 84 percent (Shedd, 1991). Stage II controls are already in place in the District of Columbia, in St. Louis, Missouri, and in parts of California. Emissions in these areas were revised to reflect these controls.

Table VI.6

Civil Aircraft SO_2 Emission Factors

Engine Type	Fuel Rate (lbs/hr)	AP-42 SO_2 Emission Factor (lbs/hr)	New SO_2 Emission Factor (lbs/hr)	Engine Type	Fuel Rate (lbs/hr)	AP-42 SO_2 Emission Factor (lbs/hr)	New SO_2 Emission Factor (lbs/hr)
250B17B	63	0.06	0.03	PT6A-41	147	0.15	0.08
	265	0.27	0.14		510	0.51	0.28
	245	0.25	0.13		473	0.47	0.26
	85	0.09	0.05		273	0.27	0.15
501D22A	610	0.61	0.33	Dart RDa7	411	0.41	0.22
	2376	2.38	1.28		1409	1.41	0.76
	2198	2.2	1.19		1248	1.25	0.67
	1140	1.14	0.62		645	0.65	0.35
TPE-331-3	112	0.11	0.06	0-200	8.24	0	0.00
	458	0.46	0.25		45.17	0.01	0.00
	409	0.41	0.22		45.17	0.01	0.00
	250	0.25	0.14		25.5	0.01	0.00
JT3D-7	1013	1.01	0.55	TSIO-360C	11.5	0	0.00
	9956	9.96	5.38		133	0.03	0.01
	8188	8.19	4.39		99.5	0.02	0.01
	3084	3.08	1.67		61	0.01	0.01
JT9D-7	1849	1.85	1.00	O-320	9.48	0	0.00
	16142	16.14	8.72		89.1	0.02	0.01
	13193	13.19	7.12		66.7	0.01	0.01
	4648	4.65	2.51		46.5	0.01	0.01
PT6A-27	115	0.12	0.06				
	425	0.43	0.23				
	400	0.4	0.22				
	215	0.22	0.12				

SOURCE: * EPA, 1991b.

Petroleum refinery fugitives and gasoline bulk plants and terminals are covered by existing CTGs and are included in many State regulations. Emissions were revised to reflect these controls in areas with regulations (Battye, 1987). Control efficiencies assumed for these area source categories were 43 percent for petroleum refinery fugitives and 51 percent for gasoline bulk plants and terminals. NAPAP area source estimates have control levels built into these emission estimates. These control levels were first backed out of the emission estimates. In areas with no controls, the emissions remained at uncontrolled levels. In areas with regulations, the uncontrolled emissions were reduced to reflect the above efficiencies.

All emission estimates incorporating control efficiencies were then revised to incorporate rule effectiveness assumptions. Control efficiencies were discounted to reflect an 80 percent rule effectiveness.

E. CORRESPONDENCE TO AMS

The last step in the creation of the area source inventory was the matching of NAPAP categories to the new AMS categories. This matching is provided in Table VI.7. Note that there is not always a one-to-one correspondence between NAPAP and AMS categories. For example, the gasoline marketing NAPAP category was split into two separate AMS categories representing Stage I and Stage II emissions. In addition, three NAPAP SCCs are not covered under the AMS system of codes. Therefore, AMS codes were created for process emissions from pharmaceutical manufacture and synthetic fiber manufacture and for SOCMI fugitive emissions.

F. EMISSION SUMMARY

An emission summary by major category for the area source inventories is shown in Table VI.8.

Table VI.7

AMS to NAPAP Source Category Correspondence

AMS SCC	Category	NAPAP SCC	Category
Stationary Source Fuel Combustion			
2102001000	Industrial - Anthracite Coal (Total: All Boiler Types)	13	Industrial Fuel - Anthracite Coal
2102002000	Industrial - Bituminous/Subbituminous Coal (Total: All Boiler Types)	14	Industrial Fuel - Bituminous Coal
2102004000	Industrial - Distillate Oil (Total: Boilers & IC Engines)	16	Industrial Fuel - Distillate Oil
2102005000	Industrial - Residual Oil (Total: All Boiler Types)	17	Industrial Fuel - Residual Oil
2102006000	Industrial - Natural Gas (Total: Boilers & IC Engines)	18	Industrial Fuel - Natural Gas
2102008000	Industrial - Wood (Total: All Boiler Types)	19	Industrial Fuel - Wood
2102009000	Industrial - Coke (Total: All Boiler Types)	15	Industrial Fuel - Coke
2102010000	Industrial - Process Gas (Total: All Boiler Types)	20	Industrial Fuel - Process Gas
2103001000	Commercial/Institutional - Anthracite Coal (Total: All Boiler Types)	7	Commercial/Institutional Fuel - Anthracite Coal
2103002000	Commercial/Institutional - Bituminous/Subbituminous Coal (Total: All Boiler Types)	8	Commercial/Institutional Fuel - Bituminous Coal
2103004000	Commercial/Institutional - Distillate Oil (Total: Boilers & I.C. Engines)	9	Commercial/Institutional - Distillate Oil
2103005000	Commercial/Institutional - Residual Oil (Total: All Boiler Types)	10	Commercial/Institutional - Residual Oil
2103006000	Commercial/Institutional - Natural Gas (Total: Boilers & I.C. Engines)	11	Commercial/Institutional - Natural Gas
2103008000	Commercial/Institutional - Wood (Total: All Boiler Types)	12	Commercial/Institutional - Wood
2104001000	Residential - Anthracite Coal (Total: All Combustor Types)	1	Residential Fuel - Anthracite Coal
2104002000	Residential - Bituminous/Subbituminous Coal (Total: All Combustor Types)	2	Residential Fuel - Bituminous Coal
2104004000	Residential - Distillate Oil (Total: All Combustor Types)	3	Residential Fuel - Distillate Oil
2104005000	Residential - Residual Oil (Total: All Combustor Types)	4	Residential Fuel - Residual Oil
2104006000	Residential - Natural Gas (Total: All Combustor Types)	5	Residential Fuel - Natural Gas
2104008000	Residential - Wood (Total: Woodstoves and Fireplaces)	6	Residential Fuel - Wood

Table VI.7 (continued)

AMS SCC	Category	NAPAP SCC	Category
Mobile Sources			
2260000000	Off-Highway Vehicle - All: Gasoline	39	Off-Highway Gasoline Vehicles
2270000000	Off-Highway Vehicle - All: Diesel	44	Off-Highway Diesel Vehicles
2275001001	Aircraft - Military Aircraft (LTOs)	46	Aircraft LTOs - Military
2275020001	Aircraft - Commercial Aircraft (LTOs)	48	Aircraft LTOs - Commercial
2275050001	Aircraft - Civil Aircraft (LTOs)	47	Aircraft LTOs - Civil
2280001000	Marine Vessels - Coal	49	Vessels - Coal
2280002000	Marine Vessels - Diesel	50	Vessels - Diesel Oil
2280003000	Marine Vessels - Residual Oil	51	Vessels - Residual Oil
2280004000	Marine Vessels - Gasoline	52	Vessels - Gasoline
2285002000	Railroads - Diesel	45	Railroad Locomotives
Industrial Processes			
2301020000	Process Emissions from Pharmaceuticals (PECHAN)	106	Process Emissions from Pharmaceutical Manufacturing
2301030000	Process Emissions from Synthetic Fiber (PECHAN)	107	Process Emissions from Synthetic Fibers Manufacturing
2301040000	SOCMI Fugitives (PECHAN)	102	Fugitive Emissions From Synthetic Organic Chemical Manufacturing
2302050000	Food & Kindred Products: SIC 20 - Bakery Products (Total)	105	Process Emissions From Bakeries
2306000000	Petroleum Refining: SIC 29 - All Processes (Total)	104	Fugitive Emissions From Petroleum Refinery Operations
2310000000	Oil & Gas Production: SIC 13 - All Processes (Total)	108	Crude Oil and Natural Gas Production Fields
2399000000	Industrial Processes: NEC	99	Minor point sources
Storage & Transport			
2501050120	Petroleum & Petroleum Product Storage - Bulk Stations/Terminals: Breathing Loss (Gasoline)	103	Bulk Terminal and Bulk Plants
2501060050	Petroleum & Petroleum Product Storage - Gasoline Service Stations (Stage I: Total)	54	Gasoline Marketed (Stage I)
2501060100	Petroleum & Petroleum Product Storage - Gasoline Service Stations (Stage II: Total)	54	Gasoline Marketed (Stage II)
Waste Disposal, Treatment, & Recovery			
2601010000	On-Site Incineration - Industrial (Total)	22	On-Site Incineration - Industrial
2601020000	On-Site Incineration - Commercial/Institutional (Total)	23	On-Site Incineration - Commercial/Institutional
2601030000	On-Site Incineration - Residential (Total)	21	On-Site Incineration - Residential
2610010000	Open Burning - Industrial (Total)	25	Open Burning - Industrial

Table VI.7 (continued)

AMS SCC	Category	NAPAP SCC	Category
2610020000	Open Burning - Commercial/Institutional (Total)	26	Open Burning - Commercial/Institutional
2610030000	Open Burning - Residential (Total)	24	Open Burning - Residential
2630020000	Wastewater Treatment - Public Owned (Total)	100	Publicly-Owned Treatment Works (POTWs)
2640000000	TSDFs - All TSDF Types (Total: All Processes)	109	Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)
Miscellaneous Area Sources			
2801500000	Agriculture Production - Crops - Agricultural Field Burning (Total)	62	Agricultural Field Burning
2801520000	Agriculture Production - Crops - Orchard Heaters (Total)	63	Frost Control - Orchard Heaters
2810001000	Other Combustion - Forest Wildfires (Total)	60	Forest Wild Fires
2810010000	Other Combustion - Managed (Slash/Prescribed) Burning (Total)	61	Managed Burning - Prescribed
2810030000	Other Combustion - Structure Fires	64	Structural Fires

Table VI.8

Summary of Area Source Emissions

Category	Annual Emissions (thousand tons per year)				
	1987	1988	1989	1990	1991
VOC					
Stationary Source Fuel Combustion	492	480	462	447	438
Mobile Sources	1,314	1,294	1,271	1,239	1,205
Industrial Processes	927	945	941	949	951
Storage and Transport	1,352	1,385	1,380	1,413	1,420
Waste Disposal, Treatment, and Recovery	2,249	2,302	2,282	2,254	2,210
Miscellaneous Area Sources	566	584	578	576	567
Total VOC	**6,898**	**6,990**	**6,915**	**6,878**	**6,789**
NO_x					
Stationary Source Fuel Combustion	2,029	2,140	2,189	2,235	2,328
Mobile Sources	2,390	2,441	2,505	2,499	2,441
Industrial Processes	5	5	5	5	5
Storage and Transport	0	0	0	0	0
Waste Disposal, Treatment, and Recovery	67	66	64	63	61
Miscellaneous Area Sources	132	134	133	133	132
Total NO_x	**4,623**	**4,786**	**4,896**	**4,933**	**4,966**
CO					
Stationary Source Fuel Combustion	6,459	6,307	6,084	5,877	5,747
Mobile Sources	7,030	6,879	6,701	6,511	6,361
Industrial Processes	2	2	2	2	2
Storage and Transport	0	0	0	0	0
Waste Disposal, Treatment, and Recovery	1,778	1,730	1,672	1,611	1,570
Miscellaneous Area Sources	4,198	4,327	4,286	4,267	4,202
Total CO	**19,466**	**19,245**	**18,745**	**18,268**	**17,882**

Table VI.8 (continued)

Category	Annual Emissions (thousand tons per year) 1987	1988	1989	1990	1991
SO_2					
Stationary Source Fuel Combustion	1,086	1,071	1,034	1,021	1,094
Mobile Sources	339	353	363	366	365
Industrial Processes	2	2	2	2	2
Storage and Transport	0	0	0	0	0
Waste Disposal, Treatment, and Recovery	15	16	16	15	15
Miscellaneous Area Sources	4	4	4	4	4
Total SO_2	**1,447**	**1,446**	**1,418**	**1,408**	**1,480**

CHAPTER VII
CANADIAN EMISSIONS

The 1990 Interim Inventory includes emission estimates for three Canadian provinces: New Brunswick, Quebec, and Ontario. Point and area source emission estimates were based on the 1985 NAPAP Inventory. Mobile source VMT estimates were developed based on data provided by Environment Canada, the Canadian Environmental Ministry. Mobile source emission factors were developed using a version of MOBILE4.1 modified to reflect characteristics of the Canadian vehicle fleet.

A. POINT AND AREA SOURCES

Emission estimates for point and area sources were based on emission estimates from the 1985 NAPAP Inventory. 1985 NAPAP emissions were grown to inventory years 1987 through 1991 using data from two reports from the Canadian Council of Ministers of the Environment. One report contained provincial VOC and NO_x emission estimates for major source categories for the years 1985 and 1990 (CCME, 1990). The second report contained provincial SO_2 emission estimates for power generation, primary metals, and other sources for the years 1980 and 1987 through 1990 (EC, 1990). Growth in stationary source CO emissions was not calculated because data to calculate CO emission growth factors were not available.

Source categories in the Canadian reports were matched with the NAPAP categories. Table VII.1 lists the categories used from the Canadian report and their corresponding NAPAP categories. For VOC and NO_x, average annual growth rates were calculated for each source category in each province using the 1985 and 1990 data. For SO_2, a 1985 emission estimate was calculated assuming straight line growth between 1980 and 1987. An average annual growth rate was then calculated for each source category in each province using the 1985 and 1990 data. Table VII.2 lists the growth rates calculated for each source category in each province. These growth rates were applied to the 1985 NAPAP data to calculate emission estimates for the years 1987 through 1991. Table VII.3 lists point source emission estimates by major source category. Table VII.4 lists the area source emission estimates.

B. MOBILE SOURCES

Canadian VMT estimates were developed using province-specific vehicle registration and national average VMT (per vehicle) data for 1988 supplied by Environment Canada (Lavelle and Terrillon, 1991). 1988 VMT was calculated by multiplying the number of registered vehicles for each vehicle type in each province by the average VMT for that

Table VII.1

Source Categories* Used to Project Canadian Growth

Source Categories	Point Source SCCs	Area Source SCCs
	VOC	
Transportation		
Off-Road		221xx
Other		222xx-253xx
Fuel Combustion		
Fuel Wood	102009, 103009	116xx
Res/Comm	103xxx (except 103009), 105002, 203xxx	111xx-115xx, 12xxx
Industrial	102xxx (except 102009), 105001, 202xxx	13xxx
Industrial		
Petrochemicals	301xxx (except 301018), 407xxx, 408xxx	54xxx
Petroleum	306xxx, 403xxx	
Plastics	301018, 308xxx	56000
Crude Oil	310xxx	52110
Other	302xxx-305xxx, 307xxx, 309xxx, 311xxx-399xxx	51xxx, 53xxx, 57xxx, 85xxx
Incineration/Misc		
Surface Coatings	402xxx	77000, 78200
Fuel Marketing	404xxx, 406xxx	27xxx
Dry Cleaning	401001	71000
Solvent Use	401002-401888, 490xxx	70000
Slash Burning		33100
Other	405xxx, 5xxxxx	31xxx, 32xxx
Power Generation	101xxx, 201xxx	14xxx
	NO_x	
Transportation		
Off-Road Diesel		222xx
Other		221xx, 231xx-253xx
Fuel Combustion		
Residential		11xxx
Commercial	103xxx, 105002, 203xxx	12xxx
Industrial		
Natural Gas	102006, 10500106, 202002	13100
Other	102xxx, 105001, 202xxx (except NG)	13200-13520
Industrial	3xxxxx	85xxx
Incineration/Misc	5xxxxx	31xxx, 32xxx, 33xxx
Power Generation	101xxx, 201xxx	14xxx
	SO_2	
Primary Metals		
Power Generation	101xxx, 201xxx	14xxx
Other		

NOTES: The major source categories from available Canadian Reports (CCME, 1990; EC, 1990) were to the corrresponding NAPAP SCCs.

Table VII.2

Canadian Emissions and Growth Factors

	VOC								
	New Brunswick			Quebec			Ontario		
	1985 Emissions 10^6 tons	1990 Emissions 10^6 tons	% Growth	1985 Emissions 10^6 tons	1990 Emissions 10^6 tons	% Growth	1985 Emissions 10^6 tons	1990 Emissions 10^6 tons	% Growth
Transportation									
Off-Road Gasoline	0.8	0.8	0.00	4.8	5.0	4.17	19.4	20.6	6.19
Other	1.4	1.6	14.29	10.4	10.6	1.92	21.6	23.1	6.94
Fuel Combustion									
Fuel Wood	5.3	5.2	-1.89	39.9	46.7	17.04	33.9	31.2	-7.96
Res/Comm	0.1	0.1	0.00	0.4	0.4	0.00	1.1	1.1	0.00
Industrial	0.1	0.1	0.00	0.3	0.3	0.00	1.1	1.1	0.00
Industrial Processes									
Petrochemicals	-	-	-	5.9	6.2	5.08	18.2	18.7	2.75
Petroleum Refining	1.3	1.4	7.69	7.1	7.5	5.63	15.4	16.7	8.44
Plastics	0.1	0.2	100.00	3.5	4.1	17.14	8.1	9.4	16.05
Crude Oil	0.5	0.5	0.00	0.7	0.6	-14.29	0.1	0.1	0.00
Other	0.6	0.7	16.67	8.3	9.1	9.64	30.4	32.7	7.57
Incineration/Misc									
Surface Coatings	3.8	4.1	7.89	48.5	53.9	11.13	83.3	94.6	13.57
Fuel Marketing	3.2	3.3	3.13	23.3	23.3	0.00	41.6	44.3	6.49
Dry Cleaning	0.4	0.4	0.00	3.6	3.7	2.78	5.0	5.3	6.00
Solvent Use	7.5	7.8	4.00	69.1	70.8	2.46	129.6	136.9	5.63
Slash Burning	4.5	6.3	40.00	20.2	26.2	29.70	0.5	0.6	20.00
Other	0.5	0.5	0.00	8.8	9.2	4.55	4.2	4.6	9.52
Power Generation	0.1	0.1	0.00%	0.1	0.1	0.00	0.4	0.4	0.00

Table VII.2 (continued)

NOx

	New Brunswick			Quebec			Ontario		
	1985 Emissions 10^6 tons	1990 Emissions 10^6 tons	% Growth	1985 Emissions 10^6 tons	1990 Emissions 10^6 tons	% Growth	1985 Emissions 10^6 tons	1990 Emissions 10^6 tons	% Growth
Transportation									
Off-Road Diesel	6.9	8.0	15.94	46.0	45.8	-0.43	74.0	76.1	2.84
Other	0.8	0.8	0.00	16.4	17.3	5.49	20.2	22.0	8.91
Fuel Combustion									
Residential	1.0	1.0	0.00	7.5	6.1	-18.67	15.4	14.6	-5.19
Commercial	0.6	0.5	-16.67	3.9	4.7	20.51	9.7	9.5	-2.06
Industrial									
Natural Gas	-	-	-	-	-	-	0.5	0.5	0.00
Other	3.9	4.8	23.08	21.3	24.6	15.49	45.1	50.1	11.09
Industrial Processes	2.7	3.1	14.81	6.8	7.8	14.71	38.2	40.5	6.02
Incineration/Misc	1.1	1.5	36.36	6.0	7.3	21.67	2.5	2.7	8.00
Power Generation	7.9	22.7	187.34	1.5	3.8	153.33	97.6	74.9	-23.26

Table VII.2 (continued)

Canadian Emissions and Growth Factors

SO_2

	New Brunswick					Quebec					Ontario				
	1980	1985*	1987	1990	1985-90	1980	1985*	1987	1990	1985-90	1980	1985*	1987	1990	1985-90
	Emissions 10^6 tons				% Growth	Emissions 10^6 tons				% Growth	Emissions 10^6 tons				% Growth
Primary Metals	13.00	15.86	17.00	8.00	-49.55	641.00	508.14	455.00	189.00	-62.81	1031.00	878.86	818.00	730.00	-16.94
Power Generation	122.00	147.71	158.00	141.00	-4.55	-	-	-	-	-	398.00	350.86	332.00	195.00	-44.42
Other	85.00	53.57	41.00	38.00	-29.07	457.00	272.71	199.00	207.00	-24.10	335.00	280.71	259.00	325.00	15.78

NOTES: *Calculated assuming straight-line growth from 1980 to 1987.

Table VII.3

Summary of Canadian Point Source Emissions 1987-1991

Category	Emissions (thousand tons) 1987	1988	1989	1990	1991
VOC					
External Fuel Combustion - Utilities	626	626	626	626	626
External Fuel Combustion - Industrial	1,268	1,268	1,268	1,268	1,268
External Fuel Combustion - Commercial/Institutional	0	0	0	0	0
Internal Combustion Engines	0	0	0	0	0
Chemical Manufacturing	79,233	80,550	81,865	83,181	84,494
Petroleum Refining	16,256	16,521	16,787	17,052	17,317
Primary and Secondary Metals	10,889	11,071	11,252	11,434	11,616
Mineral Products	117	119	121	123	125
Food and Agriculture Production	0	0	0	0	0
Misc. Industrial Processes	2,805	2,865	2,925	2,985	3,044
Industrial Organic Solvent Use	3,392	3,465	3,538	3,611	3,685
Petroleum Product Marketing	7,823	7,951	8,079	8,207	8,334
Organic Chemical Storage and Transportation	582	587	590	594	598
Waste Disposal	1,142	1,152	1,162	1,172	1,183
Total VOC	**124,133**	**126,175**	**128,213**	**130,253**	**132,290**
NO_x					
External Fuel Combustion - Utilities	109,704	108,136	106,569	105,002	103,434
External Fuel Combustion - Industrial	15,477	15,836	16,196	16,555	16,914
External Fuel Combustion - Commercial/Institutional	0	0	0	0	0
Internal Combustion Engines	0	0	0	0	0
Chemical Manufacturing	1,247	1,271	1,294	1,317	1,340
Petroleum Refining	12,510	12,680	12,849	13,019	13,189
Primary and Secondary Metals	12,145	12,302	12,461	12,619	12,776
Mineral Products	10,801	11,013	11,225	11,437	11,649
Food and Agriculture Production	0	0	0	0	0
Misc. Industrial Processes	11,139	11,390	11,641	11,891	12,142
Industrial Organic Solvent Use	5	5	5	5	6
Petroleum Product Marketing	19	20	20	20	21
Organic Chemical Storage and Transportation	0	0	0	0	0
Waste Disposal	577	600	622	646	668
Total NO_x	**173,624**	**173,253**	**172,882**	**172,511**	**172,139**

Table VII.3 (continued)

Category	Emissions (thousand tons) 1987	1988	1989	1990	1991
CO					
External Fuel Combustion - Utilities	5,201	5,201	5,201	5,201	5,201
External Fuel Combustion - Industrial	411	411	411	411	411
External Fuel Combustion - Commercial/Institutional	0	0	0	0	0
Internal Combustion Engines	0	0	0	0	0
Chemical Manufacturing	129,204	129,204	129,204	129,204	129,204
Petroleum Refining	50,005	50,005	50,005	50,005	50,005
Primary and Secondary Metals	481,468	481,468	481,468	481,468	481,468
Mineral Products	422	422	422	422	422
Food and Agriculture Production	0	0	0	0	0
Misc. Industrial Processes	28,758	28,758	28,758	28,758	28,758
Industrial Organic Solvent Use	500	500	500	500	500
Petroleum Product Marketing	1	1	1	1	1
Organic Chemical Storage and Transportation	0	0	0	0	0
Waste Disposal	7,552	7,552	7,552	7,552	7,552
Total CO	**703,522**	**703,522**	**703,522**	**703,522**	**703,522**
SO_2					
External Fuel Combustion - Utilities	406,819	372,911	339,003	305,096	271,188
External Fuel Combustion - Industrial	37,006	37,006	37,006	37,006	37,006
External Fuel Combustion - Commercial/Institutional	36	36	36	36	36
Internal Combustion Engines	0	0	0	0	0
Chemical Manufacturing	61,688	61,688	61,688	61,688	61,688
Petroleum Refining	48,326	48,326	48,326	48,326	48,326
Primary and Secondary Metals	1,318,586	1,218,488	1,118,390	1,018,291	918,192
Mineral Products	37,765	37,765	37,765	37,765	37,765
Food and Agriculture Production	0	0	0	0	0
Misc. Industrial Processes	38,907	38,907	38,907	38,907	38,907
Industrial Organic Solvent Use	0	0	0	0	0
Petroleum Product Marketing	43	43	43	43	43
Organic Chemical Storage and Transportation	0	0	0	0	0
Waste Disposal	469	469	469	469	469
Total SO_2	**1,949,645**	**1,815,639**	**1,681,633**	**1,547,627**	**1,413,620**

Table VII.4

Summary of Canadian Area Source Emissions

Category	Emissions (thousand tons per year)				
	1987	1988	1989	1990	1991
VOC					
Stationary Source Fuel Combustion	59,569	60,113	60,657	61,201	61,745
Mobile Sources	46,033	46,544	47,055	47,566	48,077
Industrial Processes	54,008	55,707	57,406	59,105	60,804
Storage and Transport	76,232	76,848	77,465	78,082	78,698
Waste Disposal, Treatment, and Recovery	67,738	70,956	74,174	77,392	80,610
Solvent Usage	211,406	214,779	218,151	221,523	224,896
Miscellaneous Area Sources	5,952	5,952	5,952	5,952	5,952
Total	**520,938**	**530,899**	**540,860**	**550,821**	**560,782**
NO_x					
Stationary Source Fuel Combustion	99,998	100,687	101,376	102,065	102,754
Mobile Sources	159,474	160,789	162,104	163,421	164,736
Industrial Processes	27	27	28	28	29
Storage and Transport	0	0	0	0	0
Waste Disposal, Treatment, and Recovery	13,483	13,919	14,357	14,794	15,231
Solvent Usage	0	0	0	0	0
Miscellaneous Area Sources	424	424	424	424	424
Total	**273,406**	**275,846**	**278,289**	**280,732**	**283,174**
CO					
Stationary Source Fuel Combustion	52,557	52,557	52,557	52,557	52,557
Mobile Sources	142,133	142,133	142,133	142,133	142,133
Industrial Processes	0	0	0	0	0
Storage and Transport	0	0	0	0	0
Waste Disposal, Treatment, and Recovery	658,906	658,906	658,906	658,906	658,906
Solvent Usage	0	0	0	0	0
Miscellaneous Area Sources	20,997	20,997	20,997	20,997	20,997
Total	**874,593**	**874,593**	**874,593**	**874,593**	**874,593**

Table VII.4 (continued)

Category	Emissions (thousand tons per year)				
	1987	1988	1989	1990	1991
SO_2					
Stationary Source Fuel Combustion	229,286	229,286	229,286	229,286	229,286
Mobile Sources	4,620	4,620	4,620	4,620	4,620
Industrial Processes	2,459	2,456	2,454	2,451	2,448
Storage and Transport	0	0	0	0	0
Waste Disposal, Treatment, and Recovery	826	826	826	826	826
Solvent Usage	0	0	0	0	0
Miscellaneous Area Sources	0	0	0	0	0
Total	**237,191**	**237,188**	**237,186**	**237,183**	**237,180**

vehicle type. VMT was projected to the other inventory years using a VMT growth rate of 1.76 percent for New Brunswick, 2.07 percent for Quebec, and 2.17 percent for Ontario (Pechan, 1992b). Table VII.5 lists VMT estimates by province for 1990.

Emission factors for highway vehicles were calculated using a version of EPA's MOBILE4.1 that was modified to reflect the characteristics of the Canadian vehicle fleet. Environment Canada provided instructions on adapting MOBILE4 to the Canadian fleet (Lavallee and Terrillon, 1991; Lavallee, 1991). This information was used to adapt MOBILE4.1 rather than MOBILE4. The major differences between the Canadian version of MOBILE4.1 and the U.S. version are the basic emission factor equations used to model the 1980 through 1987 model years. The emission control technology and the emissions performance of vehicles for these model years differed significantly between Canada and the United States. To reflect these differences, the technology penetration rates were also modified within the MOBILE4.1 computer code for these model years.

Table VII.5

1990 Canadian VMT Estimates
(millions of vehicle miles traveled)

New Brunswick		Ontario		Quebec	
Vehicle Type	VMT	Vehicle Type	VMT	Vehicle Type	VMT
LDGV	3,515	LDGV	53,760	LDGV	34,888
LDGT	1,100	LDGT	8,817	LDGT	3,862
HDGV	266	HDGV	1,286	HDGV	630
LDDT	99	LDDT	792	LDDT	347
HDDV	516	HDDV	4,460	HDDV	1,781
Total	**5,495**	**Total**	**69,115**	**Total**	**41,508**

CHAPTER VIII
QUALITY ASSURANCE AND QUALITY CONTROL

Integral to any inventory effort of this magnitude is a quality assurance/quality control plan which will ensure the integrity and reasonableness of the data. The complexity of the algorithms, the size of the data bases, and the number of outside data sources used to create these inventories mandates a structured and well-documented quality assurance plan. Data results should also be compared with other sources, since identifying and explaining differences helps verify the accuracy of the data.

The first section of this chapter describes the routine procedures followed during the development of the Interim Inventories. The following sections provide specific details on the quality assurance procedures implemented for each inventory. The last sections of this chapter include a comparison of the 1990 Interim Inventory data with the 1990 *Trends* data and a comparison between the 1985 NURF and the NADB.

A. DATA AND PROGRAM INTEGRITY ASSURANCE

During the course of the Inventory development, several procedures were followed to assure data and program integrity. These routine checks included the following:

Routine Data Base Checks:

- Checking for duplicate records.
- Checking for negative emissions.
- Checking for blank SCCs, State codes, county codes, and other required data elements.

Data Entry:

- Data entered into the computer (i.e., activity data used for growth) were verified by checking State and national totals against the published values.
- Data were reviewed by a second person.

Program Calculations:

- Calculations were routinely corroborated by an independent person to confirm that the correct algorithms were being applied and that the correct data were being used for each calculation (e.g., the correct growth factor was used for the State SIC combination).

Reasonableness Checks on Emission Estimates:

- The emission values were routinely checked against other data sources as a reasonableness check.

B. QUALITY ASSURANCE OF UTILITY INVENTORIES

1. Emission Estimates

Quality assurance was performed on 1990 steam electric utility emissions data for a sample of eight plants. Emissions of SO_2, NO_x, CO, and VOC were calculated for the sample as a check against the emissions calculated by the program. Spreadsheets were used to calculate the emissions based on the written Form EIA-767 1990 fuel use data and emission factors corresponding to SCC codes. The sample of plants included EC Gaston, Paradise, Monroe, Bruce Mansfield, Martin Lake, General JM Gavin, and Quindaro and Reeves. SO_2 emissions were calculated for six of the plants. CO and VOC emissions were each calculated for one plant. NO_x emissions calculations were performed on four plants: three with control equipment (and various fuel use) and one without controls. Quality assurance results by pollutant are summarized below.

a. SO_2

SO_2 emissions were calculated for six of the plants in the sample. Emissions figures matched exactly for all boilers without a scrubber efficiency, with the exception of General JM Gavin's oil SO_2 emissions. A comparison was made between the computerized raw EIA-767 data and the written Form EIA-767. In this case, the total on the form did not match the raw computerized data because February's fuel use was different. The computerized data were used.

For plants with scrubber efficiencies (Paradise, Bruce Mansfield, and Martin Lake), all SO_2 emissions data matched, with the exception of Bruce Mansfield Boiler 3. As with General JM Gavin, the monthly oil total for this unit did not match the fuel quantity reported in the Inventory. Again, raw computerized EIA-767 data were compared with the actual Form EIA-767, and were found to be different in August fuel use. The computerized data were used.

In summary, SO_2 emissions data are accurate both for boilers with scrubbers and those without scrubbers.

b. CO

CO emissions were calculated for Boiler 1 at EC Gaston. The calculated emissions matched the emissions from the Inventory. CO emission calculations appear to be accurate, based on this calculation.

c. VOC

VOC emissions were calculated for Boiler 2 at EC Gaston. As with CO, the calculation matched, and it appears that the method for VOC emissions calculations is correct.

d. NO_x

NO_x emissions were calculated first for Monroe, a plant without NO_x controls, for Bruce Mansfield, and for Quindaro and Reeves (gas fuel use) -- plants which all have NO_x controls. In all cases, emissions matched exactly with the Inventory estimate. It is believed that NO_x emissions for boilers both with and without controls are accurate.

2. *Coverage of Plants*

Quality assurance was performed on two States in the 1988, 1989, and 1990 utility files developed by Pechan. The goal of the cross-examination was to ensure that all plants listed in the *Inventory of Power Plants in the United States, 1988, 1989, and 1990* (DOE, 1989-1991) were included in the steam inventories, and vice versa. Steam electric utilities in Alabama and Pennsylvania were cross-checked as a sample.

For Alabama, the data sets matched exactly for all 3 years. For Pennsylvania, there was a discrepancy between the data sets for all 3 years. The discrepancy involved two plants (F.R. Phillips and Springdale) that were in the *Inventory of Power Plants*, but not in the steam electric utility inventories. Upon further examination of EIA-767 data, it was determined that these two plants were not in the inventory files because they had no fuel use during the period from 1988 to 1990.

C. QUALITY ASSURANCE OF NON-UTILITY POINT SOURCES

After completion and initial debugging of the non-utility point source program, a sample of records were hand-checked to ensure that all calculations were correct and that the programs were selecting the appropriate growth data for each record (based on the SIC). Inventory input and output records were then printed along with the growth data for a sample State. The growth calculation was first verified by looking up the appropriate earnings data and verifying the grown emission estimate. No errors were detected in the calculation. Next, the rule effectiveness calculation was verified by back-calculating the uncontrolled emissions (based on the reported efficiency) and calculating the revised emission estimate by discounting the efficiency by 80 percent. It was verified that the rule effectiveness calculation was completed by the program for VOC, NO_x, and CO emissions. The SO_2 emissions were estimated assuming 100 percent rule effectiveness.

After verification that the projection algorithms were correct, national emission totals by pollutant were produced and average growth per year was checked for reasonableness.

D. QUALITY ASSURANCE OF MOTOR VEHICLE DATA

After estimating VMT for 1990, State totals for each of the 12 roadway types were computed. These totals were compared with the values in Table VM-2, "Annual Vehicle-Miles of Travel -- 1990" in *Highway Statistics 1990* (FHWA,1991). The VMT estimates calculated for the 1990 Interim Inventory exactly matched the VMT values in *Highway Statistics* for every roadway type in every State (except for differences due to rounding). The national VMT total calculated for 1990 differed by only .08 percent from the national total in *Highway Statistics*.

County-level annual VMT estimates for Maryland for 1990 were obtained from Maryland's Department of the Environment. These VMT estimates were compared with the VMT estimates computed for the 1990 Interim Inventory. Total VMT for Maryland was the same for both sources. Figure VIII.1 shows how the county distribution of VMT data for the State of Maryland compared with the county distribution of VMT computed for the Interim Inventory.

Additional quality control for the VMT values was performed for Arizona, Maryland, and Pennsylvania. The percentage of total VMT occurring in each county was calculated for these three States, and these percentages were compared with values similarly derived from the 1985 NAPAP Inventory. This comparison suggested that the VMT distribution calculated for the 1990 Interim Inventory was similar to that used in the 1985 NAPAP Inventory. Figure VIII.2 shows how the 1985 NAPAP county VMT distribution compares with the 1990 Interim Inventory county VMT distribution for Arizona.

The distribution of VMT among the different vehicle types was also checked by comparing the vehicle distribution of VMT calculated for this Inventory with the vehicle distribution of VMT in the 1985 NAPAP Inventory for New Jersey, Texas, and Washington. The LDGV, LDGT, HDGV, and HDDV percentages of VMT were compared to corresponding values calculated from the 1985 NAPAP Inventory. The LDDV and LDDT categories were not included in this comparison because they were not accounted for in the 1985 NAPAP data. LDGV and HDGV percentages were slightly higher in the 1985 data, while the LDGT percentage was slightly higher in the 1990 data. These variations were attributed to the different methods of VMT computation used in the two inventories. Figure VIII.3 shows the comparison described above for New Jersey.

E. QUALITY ASSURANCE OF SOLVENT INVENTORIES

A major portion of the quality assurance effort for the solvents Inventory included filling in missing data in the census allocation data bases. This results from the practice of withholding employment data in cases where a given county contains only a few facilities. Missing data were filled in based on other census data, such as the number of facilities in various size ranges.

Figure VIII.1

Comparison of Maryland County VMT

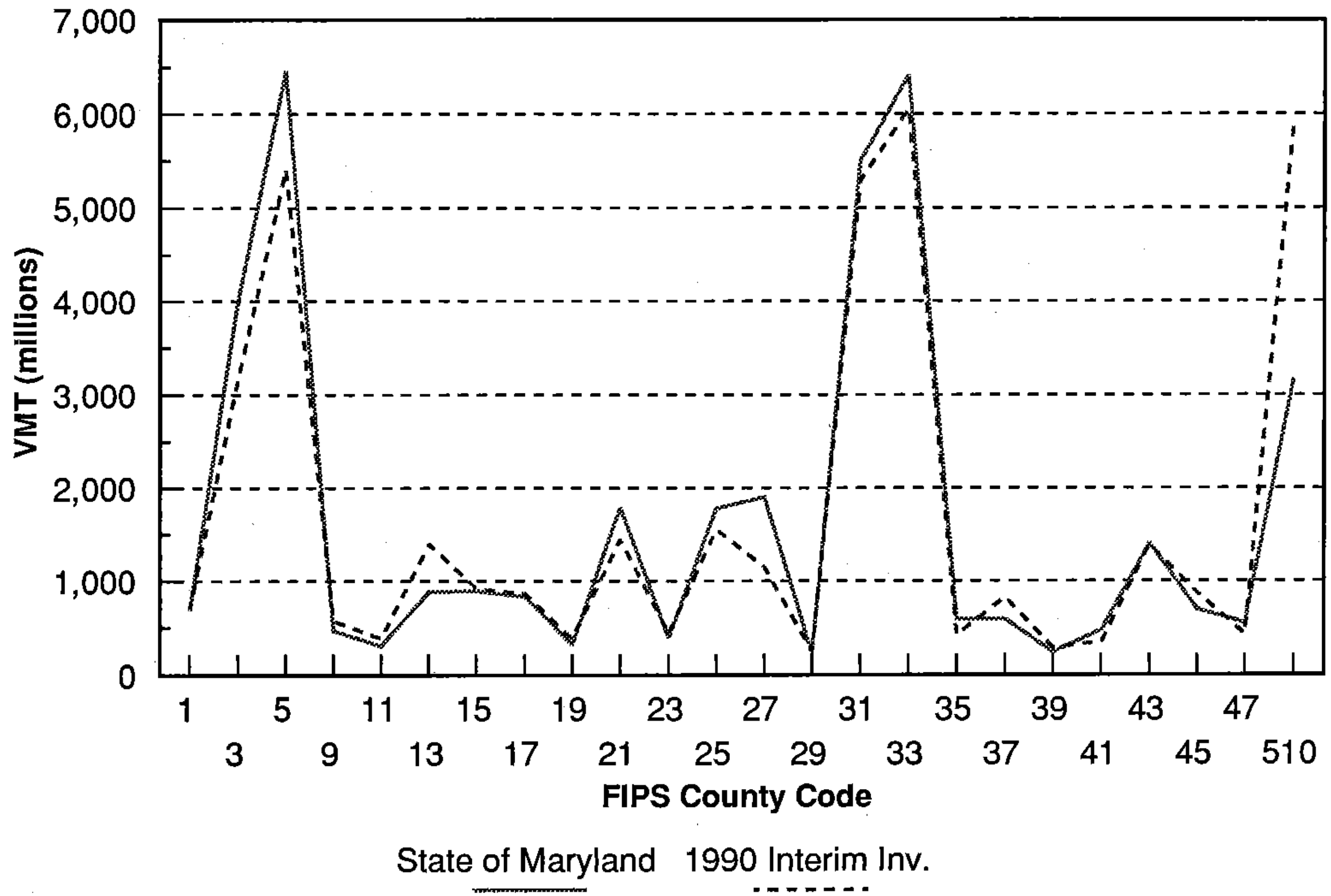


Figure VIII.2

Comparison of Arizona County VMT Distribution

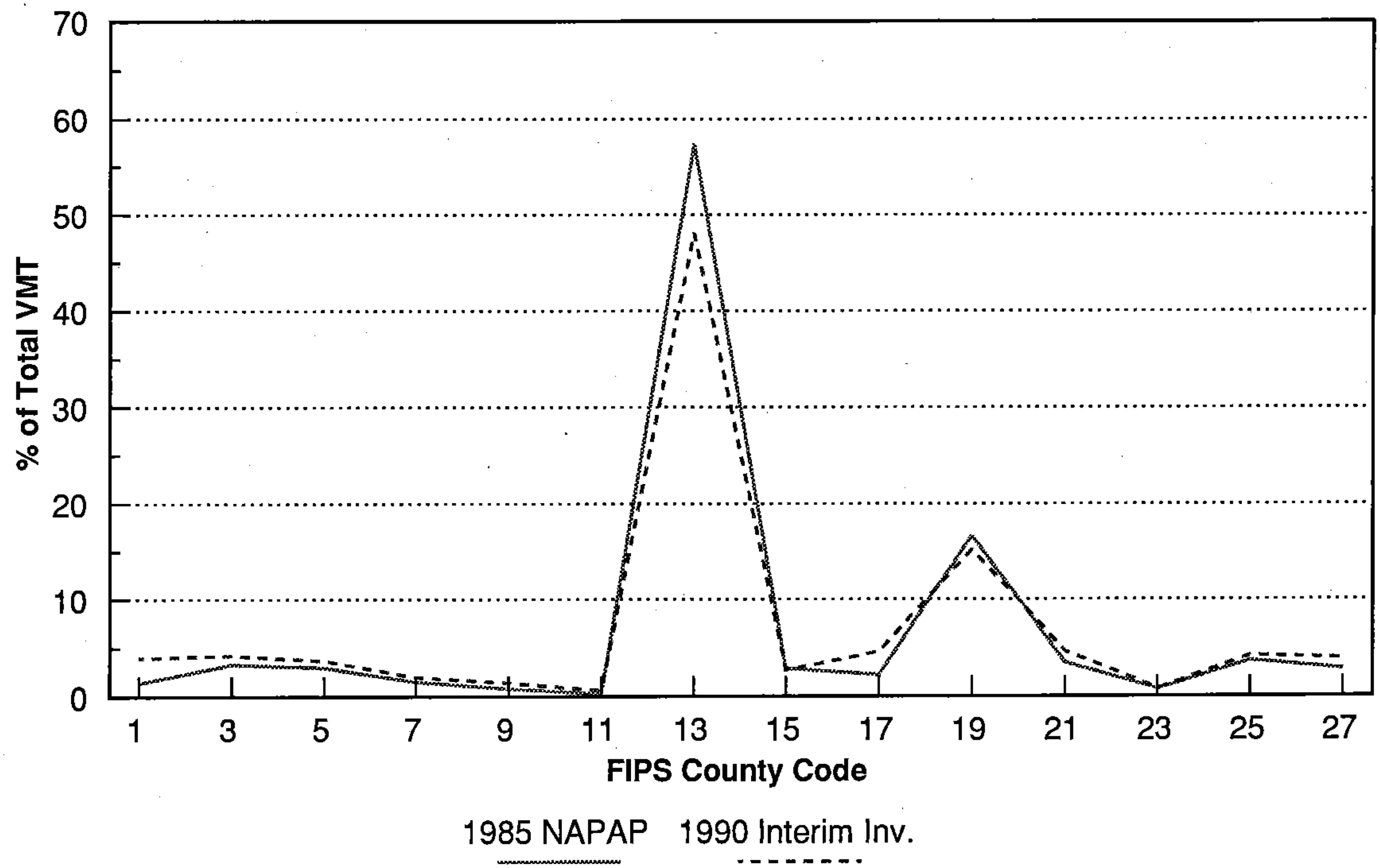
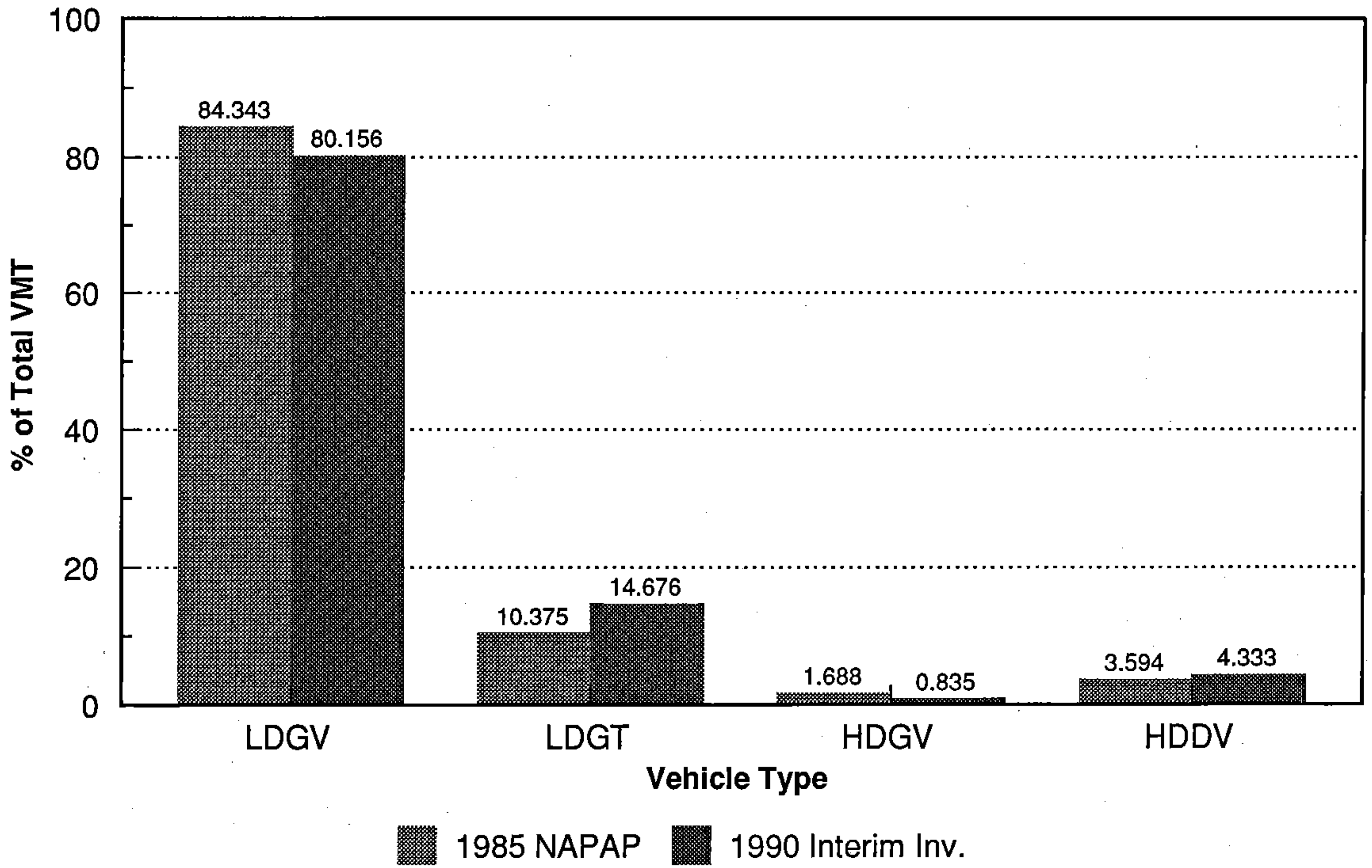


Figure VIII.3
Comparison of
New Jersey Vehicle Type VMT Distribution



After completion of the solvent inventory, the data base was scanned to check for missing States and duplicate records. It was discovered that several categories were duplicated for Alabama. Further investigation showed that the original census allocation data base had duplicates for this State. This error was corrected and the solvent emissions were recalculated.

To further ensure that the calculations and allocation procedures are correct, the solvent emissions were totaled by category and the sum was verified against the initial solvent material balance.

F. QUALITY ASSURANCE OF AREA SOURCE INVENTORIES

After the final area source inventory program was completed and debugged, the emission calculations were checked for a sample of 14 area source records to ensure program integrity. Printouts of the base year (1985 NAPAP) emissions data, the growth rate data, and emission factor changes were produced. The base year data were used to find the appropriate growth factor and emission factor change. Inventory year emissions were calculated and checked against the values produced by the program. No errors were found.

After completion of the 1990 Inventory, national totals of emissions were produced and compared with 1985 values to ensure reasonableness of overall emission totals. State/SCC combinations showing higher than 100 percent changes were reviewed in more detail. Residual oil combustors exhibited high fluctuations in emissions compared with other categories. DOE personnel were contacted to review the source for these data. It was found that, due to the nature of the fuel market, residual fuel shows high fluctuations in use. It was determined that the California value for 1985 was in error, so this value was changed by interpolating data from other years. There was no indication that other values were in error.

Routine scans for blank data found that FIPS county codes were missing for two counties: Washabaugh, South Dakota, and Nesmond, Virginia. Contact with Virginia air pollution personnel indicated that Nesmond County was absorbed by Suffolk in the 1970s. No emissions appeared in the Inventory for Suffolk, so the FIPS county code was changed to Suffolk. A comparison of road atlases for different years showed that Washabaugh became Jefferson County. The emission records for Washabaugh appeared to be duplicates of records for Jefferson County, so they were deleted from the Inventory.

Petroleum refinery emissions were re-estimated for the area source Inventory as described in Chapter VI. The associated program and data also underwent extensive QA. Initial review showed that the negative values (counties with point source emissions higher than the estimated total) were allocated to other counties incorrectly -- the values were added to other counties instead of subtracted, producing higher national emissions. This was corrected.

After completion of the area source refinery fugitive emissions, the county-level shares of emissions for the new Inventory were compared with those in the 1985 NAPAP Inventory. Since emissions are allocated to counties based on the share of refinery capacity, differences in percentages of total area source emissions would indicate that the capacities used in the allocation differed between the Interim Inventory and NAPAP. The county level capacity was determined by matching each facility from the Petroleum Supply Annual to a county based on (1) matching the facility with a NAPAP facility and using the county reported in NAPAP, or (2) locating the facility based on the city listed in the Petroleum Supply Annual (DOE, 1991c).

Review of the county allocations identified one refinery in Louisiana which was incorrectly located. This was corrected and the area source emissions were re-allocated. There were remaining counties which showed higher/lower allocations of area source refinery fugitive emissions. The location of refineries was double-checked for these counties. In most cases, the capacity was allocated by matching the refinery to a NAPAP facility so area source emissions appeared in counties with existing point source facilities. This scenario appears more likely than allocating area source emissions to counties in which no point source refineries exist, which is the case for the 1985 NAPAP Inventory.

G. COMPARISON WITH TRENDS

A comparison of the 1990 *Trends* and the 1990 Interim Inventory by major category is shown in Table VIII.1. A comparison of VOC emissions shows the Interim Inventory estimate to be about 2 million tons (10 percent) higher than the *Trends* estimate. The major categories contributing to this difference are industrial processes and solid waste disposal. Total NO_x emissions match more closely between the Interim Inventory and *Trends*, although individual categories exhibit some differences. The Interim Inventory CO emissions are 4.5 million tons (approximately 7 percent) higher than the *Trends* estimate. Motor vehicles show the biggest difference followed by the miscellaneous categories. The Interim Inventory SO_2 emissions are about 0.5 million tons (2 percent) lower than the *Trends* estimate.

1. Utility Comparison

Table VIII.1 shows that the 1990 Interim Inventory utility emissions are higher for SO_2 and lower for NO_x when compared to the *Trends* utility emissions. Using the 1987 to 1990 steam electric utility inventories (this excludes internal combustion which is included in the non-utility point source inventory elsewhere in this report), emission summaries by State, fuel type and State, and 6-digit SCC were calculated for each emission year. These tables were compared with the electric utility data from the 1990 *Trends* report (EPA, 1991a). There were a number of differences that can be attributed to differing methodologies. Among the methodological differences were the following:

- Different fuel quantities which resulted from differing report requirements -- For the steam inventories, actual reported (and computerized) *fuel burned* data from electric utility plants of at least 10 MW were used. For *Trends*, aggregate reports of *fuel received* from plants of at least 50 MW were gathered from a variety of DOE/EIA sources. There is no assurance that these data for *Trends* include the same plants; even the Form EIA-767 steam boiler data, when aggregated at the plant level, do not exactly match the Form EIA-759 plant-level fossil-fuel steam data.

Table VIII.1

Comparison of 1990 Interim Inventory and *Trends* Emissions (thousand tons)

Category		Interim Inventory	*Trends**
Highway Vehicle			
	VOC	5,075	5,617
	NO_x	6,411	6,167
	CO	43,719	33,370
	SO_2	611	661
Non-Highway Mobile			
	VOC	1,239	1,432
	NO_x	2,499	2,093
	CO	6,511	8,040
	SO_2	366	330
Utility Fuel Combustion[1]			
	VOC	33	0
	NO_x	7,516	8,040
	CO	313	330
	SO_2	15,854	15,639
Non-Utility Fuel Combustion			
	VOC	693	881
	NO_x	4,007	4,295
	CO	6,397	7,930
	SO_2	3,250	3,194
Industrial Processes			
	VOC	10,415	8,921
	NO_x	836	661
	CO	7,811	5,176
	SO_2	2,646	3,414
Solid Waste Disposal			
	VOC	2,267	661
	NO_x	81	110
	CO	1,687	1,872
	SO_2	37	0
Miscellaneous[2]			
	VOC	2,682	2,974
	NO_x	133	330
	CO	4,267	9,471
	SO_2	4	0
TOTAL			
	VOC	22,404	20,486
	NO_x	21,483	21,696
	CO	70,705	66,189
	SO_2	22,768	23,238

NOTES: [1] The utility emissions reported here include internal combustion.
[2] Includes forest fires, agricultural burning, coal refuse burning, structural fires, nonindustrial organic solvent use.

SOURCE: * EPA, 1991. (The *Trends* values were converted to short tons for ease of comparison.)

- Different ways of typing fuel data -- For the steam inventories, fuel was categorized as explained in Chapter II. The coal subcategories included bituminous, subbituminous, and lignite (anthracite fuel consumption is insignificant). For *Trends*, the coal data were subcategorized as anthracite or bituminous/lignite.

- Different sulfur contents were used to calculate SO_2 emissions -- For the steam inventories, actual data were used. For *Trends* data, a national average was used.

- Different emission factors were used to calculate SO_2 emissions -- For the steam inventories, the AP-42 factors obtained from the EPA OAQPS CHIEF Bulletin Board were used, while *Trends* utilized a method that included weighted average emission factors.

- Different ways of determining control efficiencies were used -- For the steam inventories, SO_2 control efficiency was obtained from the EIA-767 reported estimated removal efficiency at the annual operating rate; the NO_x control efficiency was derived as described earlier; and the VOC and CO control efficiencies were defaulted to be zero. For *Trends*, SO_2 control efficiencies were obtained from Flue Gas Desulfurization Information System (FGDIS) data on the plant level, and it was assumed that there were no NO_x controls.

Please note that in addition to these above differences, the 1990 emissions inventory steam portion includes only fossil-fuel steam boiler data, while the 1990 *Trends* electric utility category also includes internal combustion engines and gas turbines.

Table VIII.2 is a national comparison of 1990 fuel use, SO_2 and NO_x emissions for the fossil-fuel steam utility Interim Inventory and Trends, as well as percentage differences. As a result of the differences indicated above, overall steam inventory NO_x emissions are 7 percent less than those in *Trends*, while the overall SO_2 emissions for the steam inventory are 1 percent more than those in *Trends*. Because of the greater discrepancies in fuel use (particularly oil -- oil use in *Trends* is one-third greater than that in the Interim Inventory), the fuel emission totals indicate greater discrepancies (notably, oil NO_x emissions in *Trends* are almost one-half more than those in the Interim Inventory).

2. *Highway Vehicles*

The highway vehicle estimates of VOC and NO_x are comparable for the Interim Inventory and *Trends*. The Interim Inventory CO emissions are 10 million tons higher than the *Trends* estimated emissions. The *Trends* emission factors were modeled with EPA's MOBILE4 emission factor model. The Interim Inventory uses the updated MOBILE4.1 model. A major change to MOBILE4.1 was the incorporation of new speed correction factors for CO. Speed correction factors adjust the emission factors according to the vehicle speed. For example, MOBILE4 LDGV emission factors for CO show a continual decline with speed. MOBILE4.1 CO emission factors show a decline through 45 mph and then begin to increase with higher speeds. This difference in speed/emission factors accounts for much of the difference in the CO emission estimates, as vehicle miles traveled estimates are virtually identical.

Table VIII.2

Comparisons Between 1990 Interim Inventory and 1990 *Trends* Fuel Consumption Data

	Anth. (tons)	Bit. (tons)	Subbit. (tons)	Lignite (tons)	Total Coal (tons)	Resid. (1,000 gal)	Dist. (1,000 gal)	Total Oil (1,000 gal)	Gas (MMcf)
1990 Inventory Fuel	0.0	470,409,100.0	226,936,800.0	77,986,500.0	775,332,400.0	7,752,032.4	280,240.8	8,032,273.2	2,531,131.6
1990 *Trends* Fuel	753,000.0	772,000,000.0	0.0	0.0	772,753,000.0	9,655,300.0	1,053,000.0	10,708,300.0	2,786,100.0
Difference (%)		(64.1)	100.0	100.0	0.3	(24.6)	(275.7)	(33.3)	(10.1)

Comparisons Between 1990 Interim Inventory and 1990 *Trends* Emissions Data

	Anth. (tons)	Bit. (tons)	Subbit. (tons)	Lignite (tons)	Total Coal (tons)	Resid. (tons)	Dist. (tons)	Total Oil (tons)	Gas (tons)	Total (tons)
1990 Inventory NO_x	0.0	4,610,044.8	1,704,691.3	397,759.5	6,712,495.5	192,387.2	3,131.4	195,518.6	559,388.6	7,467,420.8
1990 *Trends* NO_x					7,072,356.8			300,927.9	647,050.1	8,020,334.8
Difference (%)					(5.3)			(43.3)	(15.7)	(.07)
1990 Inventory SO_2	0.0	13,352,190.2	1,420,672.2	437,786.9	15,210,649.3	602,700.7	9,554.9	612,255.6	756.7	15,823,661.6
1990 *Trends* SO_2					14,990,177.1			702,165.1	1,102.3	15,693,444.5
Difference (%)					1.5			9.9	(45.7)	.01

3. *Additional Category Comparisons*

For stationary source VOC, NO_x, and CO emitters, the incorporation of an 80 percent rule effectiveness factor in the Interim Inventory calculations would, all else being equal, make the Interim Inventory values higher than the corresponding *Trends* values. This is a factor in the higher industrial process emission estimates for the Interim Inventory when compared with *Trends* (except for SO_2, where no rule effectiveness factor is applied). The other overall observation about the data is that differences in the 1990 estimates would be expected to parallel differences in the 1985 NAPAP Inventory when compared with 1985 *Trends* for source categories where 1990 values are grown from NAPAP values.

The discrepancy in the VOC emission estimates for solid waste disposal results from the large VOC emission estimate in the hazardous waste TSDF emission file. Further investigation of *Trends* procedures for estimating solvent emissions in general, and hazardous waste TSDF emissions in particular, is needed before any specific changes to *Trends* can be recommended.

The miscellaneous category shows large differences in CO emission estimates, with the Interim Inventory estimate over 5 million tons (55 percent) lower than the *Trends* estimates. *Trends* estimates 8.9 million tons of CO from forest fires, compared with 1.2 million tons in the Interim Inventory (the Interim Inventory estimate is the same as the 1985 NAPAP value). The CO emission factor is the same for both emission estimates, so the differences are solely attributable to differences in estimated activity levels, or acres burned. The 1985 *Trends* estimate of CO emissions from forest fires is 7.2 million tons -- lower than the 1990 *Trends* but still significantly higher than the NAPAP estimate. This difference suggests that either NAPAP underestimated, or *Trends* overestimated the acres burned.

H. COMPARISON BETWEEN THE 1985 NURF AND THE NADB

In 1989, EPA began efforts to create a single and complete data base for utility combustion sources in anticipation of the need to support a market-based system of acid rain controls. EPA chose the 1985 National Utility Reference File (NURF) data (EPA, 1989e), augmented by additional information from the DOE/EIA, as the starting point for the development of the National Allowance Data Base (NADB) (Pechan, 1992c). The NADB Version 2.1 will be utilized for calculating SO_2 emissions allowances (credits), as delineated by Title IV of the CAA (PL, 1990).

The 1985 NURF is a comprehensive, utility-related data file that was included as one research component of the response to NAPAP, whose Emissions and Controls Task Group sponsored work both in developing estimates of current emissions from the utility industry and in projecting future emissions. The NURF data, on a generating unit level, included identification data; fuel quantity and quality data; and SO_2, NO_x, total suspended particulates (TSP), and VOC emissions and their associated rates, annualized rates, limits, control devices, and control efficiencies.

The NADB Version 2.1 data and the underlying NURF data from which it was developed have undergone several stages of careful review. After the release of the 1985 NURF in November 1989, the EPA regions were asked to review their States' data in summer 1990, prior to the release of the NADB Version 1.0 in October 1990. EPA, during fall 1990 and spring 1991, evaluated the results of this review and subsequently released the NADB Version 2.0 in June 1991. The utilities had the opportunity to review the data base during a 45-day public comment period during summer 1991, and during the fall and winter of 1991 and 1992; Version 2.1 was produced in May 1992.

Both the NURF and the NADB contain SO_2 emissions, total heat input, and SO_2 emission rates for 1985. The most important differences between the 1985 NURF and the NADB are as follows:

- The initial source of most data elements in the NURF was the NAPAP Emissions Inventory (Version 2), supplemented by the Form EIA-767, Form EIA-759, and Form FERC-423, whereas the source of the data in the NADB was primarily the 1985 NURF and the Form EIA-767, supplemented by the Form EIA-759. Unfortunately, boiler-level Form EIA-767 data and point source-level NAPAP data are not necessarily congruent. (Both NURF and the NADB utilized the Form EIA-860 and Form EIA-861 identification data as the basis for building the observations for the data bases.)

- The NADB observation is at the boiler generating unit level so as to accurately account for situations in which there is not a one-to-one correspondence between boiler and generator (the "multi-header" situation), whereas the NURF observation is solely on the generating unit level so that a one-to-one correspondence was artificially forced among EIA boilers, EIA generators, and NAPAP point sources.

- In preparing the NADB, the NURF data were extensively reviewed and data inconsistencies were eliminated through contact with State and local air agencies and utilities.

- In the NADB, individual fuel quantity and quality data that are in the NURF were replaced by a single total heat input data element, and only emission-related data for SO_2 were retained. Boiler and firing type data were eliminated from the NADB, as was the retirement date; however, in addition to generator on-line dates, the NADB also includes boiler on-line dates.

- The methodologies for developing the annualized SO_2 emission rate differ.

The NURF was developed primarily as a research tool using the best information reasonably available from public sources. No attempt was made to explore plant data not customarily reported to public agencies at the Federal or State level. In contrast, the NADB is predominantly a regulatory data base with each ton of allowances having a real annuity value of approximating $5,000 or more in 1992 dollars (assuming a 4 percent real discount rate). As a result, the focus of intensive utility reviews of the NADB has been on justifying higher initial allowance values.

After 2 years of review and scrutiny, the emissions totals in the NADB are approximately 1.2 percent higher than the corresponding emissions data in the NURF.

CHAPTER IX
COMPUTER FILES

IBM mainframe computer files were provided to EPA for each of the inventories included in the 1990 Interim Inventory. Table IX.1 lists all of the files provided under this work assignment. This chapter provides documentation of the file structures and summarizes changes which will be made to the mainframe files.

A. U.S. INVENTORIES

1. Point Source - Utilities (Fossil-Fuel Steam)

The 1987 through 1991 fossil-fuel steam utility emission inventory data files were provided in SAS format. The structure for these inventories is shown in Table IX.2.

2. Point Source - Non-Utilities

ASCII text format data files were provided for the point source inventories. The structure for the data files is shown in Table IX.3.

Because these files were derived from the 1985 NAPAP, the Air Pollution Control District (APCD) codes were retained for the State of Massachusetts. These APCD codes will be converted by EPA to county codes based on the AIRS Geographic Information Subsystem (GIS).

3. Highway Vehicles

Two files were provided for each inventory year for highway vehicles: county-level VMT estimates and State-level emission factors. The structure for the VMT data files is provided in Table IX.4. The emission factor file structure is shown in Table IX.5.

The VMT for the State of Massachusetts was originally provided by APCD. Substitute VMT files were later provided for Massachusetts by county. This data will replace the APCD-level VMT in the original data file.

Two additional files were provided to complete the highway vehicle inventories. The structure of the county-level I/M correspondence file is shown in Table IX.6. Table IX.6 also provides the structure for the SCC-speed correspondence file. These files provide information on which emission factor to apply to the VMT for each county/SCC combination.

Table IX.1

Interim Inventory Data Files

Inventory Description	Year 1987	Year 1988	Year 1989	Year 1990	Year 1991
United States					
Utility (Steam)	INT87UT2.SASDATA	INT88UT2.SASDATA	INT89UT2.SASDATA	INT90UT2.SASDATA	INT91UT2.SASDATA
Non-Utility Point	INT87PT.DATA	INT88PT.DATA	INT89PT.DATA	INT90PT.DATA	INT91PT.DATA
Highway Vehicles					
VMT	INT87VMT.DATA	INT88VMT.DATA	INT89VMT.DATA	INT90VMT.DATA	INT91VMT.DATA
Emission Factors	INT87EMF.DATA	INT88EMF.DATA	INT89EMF.DATA	INT90EMF.DATA	INT91EMF.DATA
County I/M Status	CNTYIM.DATA	CNTYIM.DATA	CNTYIM.DATA	CNTYIM.DATA	CNTYIM.DATA
SCC/Speed Correspondence	SCCSPD.DATA	SCCSPD.DATA	SCCSPD.DATA	SCCSPD.DATA	SCCSPD.DATA
Area - Solvents	INT87SV.DATA	INT88SV.DATA	INT89SV.DATA	INT90SV.DATA	INT91SV.DATA
Area - Other	INT87AR.DATA	INT88AR.DATA	INT89AR.DATA	INT90AR.DATA	INT91AR.DATA
AMS-NAPAP Correspondence	AMSNAPSCC.DATA	AMSNAPSCC.DATA	AMSNAPSCC.DATA	AMSNAPSCC.DATA	AMSNAPSCC.DATA
Canada					
Point	CAN87PT.DATA	CAN88PT.DATA	CAN89PT.DATA	CAN90PT.DATA	CAN91PT.DATA
Area	CAN87AR.DATA	CAN88AR.DATA	CAN89AR.DATA	CAN90AR.DATA	CAN91AR.DATA
Highway Vehicles					
VMT	CAN87UMT.DATA	CAN88UMT.DATA	CAN89UMT.DATA	CAN90UMT.DATA	CAN91UMT.DATA
Emission Factors	CAN87EMF.DAT	CAN88EMF.DATA	CAN89EMF.DATA	CAN90EMF.DATA	CAN91EMF.DATA

Table IX.2

Point Source - Fossil-Fuel Steam Utilities File Structure

No	Variable Name	Type	Description
1	FIPST	Num	FIPS State Code
2	FIPSCNY	Num	FIPS County Code
3	PNAME	Char	Plant Name
4	PLANTID	Char	Plant ID code right justified
5	BLRID	Char	Boiler ID code right justified
6	SIC	Num	Standard Industrial Classification Code (=4911 for Electric Utilities)
7	LATC	Char	Latitude (degrees North, form: ddd mm ss)
8	LONC	Char	Longitude (degrees West, form: ddd mm ss)
9	NETDC	Num	Maximum Nameplate Capacity (MW)
10	BOILCAP	Num	Boiler Design Capacity (MMBtu/hr)
11	STKHGT	Num	Stack Height (feet)
12	STKDIAM	Num	Stack Diameter (feet)
13	STKTEMP	Num	Stack Temperature (degrees F)
14	STKFLOW	Num	Exhaust Gas Flow Rate (actual ft^3/sec)
15	STKVEL	Num	Stack Gas Velocity (feet/sec)
16	SCC	Char	Source Classification Code
17	SAROAD1 - SAROAD4	Num	SAROAD Pollutant Codes for VOC(=43104), NO_x(=42603), CO(=42101), and SO_2(=42401)
18	EMISS1 - EMISS4	Num	Emissions for VOC, NO_x, CO, and SO_2 (tons per year)
19	CONPRI1 - CONPRI4	Num	Primary Control Equipment Codes for VOC, NO_x, CO, and SO_2 (CONPRI1 & CONPRI3 are always 0; CONPRI2=0(none), 24(low NO_x burner), 29(other control equip.); CONPRI4=0(none), 42(scrubber))
20	CONEFF1 - CONEFF4	Num	% Control Efficiency for VOC, NO_x, CO, and SO_2 (CONEFF1 & CONEFF3 are always 0)
21	FUELQUAN	Num	Annual Fuel Operating Rate (SCC unit*)
22	SULFCON	Num	% Fuel Sulfur Content
23	ASHCON	Num	% Fuel Ash Content
24	HEATCON	Num	Fuel Heat Content (MMBtu/SCC unit)
25	RULEFF1-RULEFF4	Num	Rule Effectiveness % for VOC, NO_x, CO, and SO_2 (RULEFF1, RULEFF2, & RULEFF3=80 and RULEFF4=100)

NOTES: *SCC units are tons (coal), thousand gallons (oil), and MMcf (gas).

File Type: SAS

Data Files:

Inventory Year	Filename
1987	INT87UT2.SASDATA
1988	INT88UT2.SASDATA
1989	INT89UT2.SASDATA
1990	INT90UT2.SASDATA
1991	INT91UT2.SASDATA

Table IX.3

Point Source - Non-Utility
File Structure

No	Variable Name	Type	Width	Description
1	PLANTID	Char	4	NAPAP Plant ID code
2	POINTID	Char	2	NAPAP Point ID code
3	STKHGT	Num	4.0	Stack Height (feet)
4	STKDIAM	Num	5.1	Stack Diameter (feet)
5	STKTEMP	Num	4.0	Stack Temperature (degrees F)
6	STKFLOW	Num	7.0	Flow Rate (ft^3/min)
7	BOILCAP	Num	5.0	Boiler Design Capacity (MMBtu/hr)
8	WINTHRU	Num	2.0	Winter Throughput %
9	SPRTHRU	Num	2.0	Spring Throughput %
10	SUMTHRU	Num	2.0	Summer Throughput %
11	FALTHRU	Num	2.0	Fall Throughput %
12	HOURS	Num	2.0	Hours/Day in Operation
13	DAYS	Num	1.0	Days/Week in Operation
14	WEEKS	Num	2.0	Weeks/Year in Operation
15	THRUPUT	Num	9.0	Operating Rate (SCC units/yr)
16	MAXRATE	Num	12.3	Maximum Design Rate (SCC units/hr)
17	HEATCON	Num	5.0	Fuel Heat Content (MMBtu/SCC unit)
18	SULFCON	Num	5.2	% Fuel Sulfur Content
19	ASHCON	Num	4.1	% Fuel Ash Content
20	STKVEL	Num	9.2	Stack Gas Velocity (feet/sec)
21	SCC	Char	8	Source Classification Code
22	AEROSST	Num	2.0	AEROS State Code
23	AEROSCNY	Num	4.0	AEROS County Code
24	FIPST	Num	2.0	FIPS State Code
25	FIPSCNY	Num	3.0	FIPS County Code
26	SIC	Num	4.0	Standard Industrial Classification Code
27	LATC	Num	9.4	Latitude (degrees)
28	LONC	Num	9.4	Longitude (degrees)
29-32	SAROAD1 - SAROAD4	Char	5	SAROAD Pollutant Codes for VOC(=43104), NO_x(=42603), CO(=42101), and SO_2(=42401)
33-36	EMF1 - EMF4	Num	10.5	Emission Factors for VOC, NO_x, CO, and SO_2 (lbs per SCC unit)
37-40	CONEFF1 - CONEFF4	Num	6.1	% Control Efficiency for VOC, NO_x, CO, and SO_2
41-44	CONPRI1 - CONPRI4	Num	3.0	Primary Control Equipment Codes for VOC, NO_x, CO, and SO_2
45-48	CONSEC1-CONSEC4	Num	3.0	Secondary Control Equipment Codes for VOC, NO_x, CO, and SO_2
49-52	ESTMET1-ESTMET4	Num	1.0	Estimation method for VOC, NO_x, CO, and SO_2
53-56	EMISS1 - EMISS4	Num	10.1	Emissions (tons per year) for VOC, NO_x, CO, and SO_2 (controlled with rule effectiveness)
57-60	RULEFF1-RULEFF4	Num	3.0	Rule Effectiveness % for VOC, NO_x, CO, and SO_2 (RULEFF1, RULEFF2, & RULEFF3=80 and RULEFF4=100)

Data Files:

File Type: ASCII Text

Inventory Year	Filename
1987	INT87PT.DATA
1988	INT88PT.DATA
1989	INT89PT.DATA
1990	INT90PT.DATA
1991	INT91PT.DATA

Table IX.4

Highway Vehicle - VMT
File Structure

No	Variable Name	Type	Width	Description
1	STATE	Char	2	FIPS State Code
2	COUNTY	Char	3	FIPS County Code
3	AMSSCC	Char	10	AMS Source Category Code
4	V_TYPE	Char	4	Vehicle Type
5	VMT	Num	9.3	Vehicle Miles Traveled (million miles/year)

Data Files:

File Type: ASCII Text

Inventory Year	Filename
1987	INT87VMT.DATA
1988	INT88VMT.DATA
1989	INT89VMT.DATA
1990	INT90VMT.DATA
1991	INT91VMT.DATA

Table IX.5

Highway Vehicle - Emission Factor File Structure

No	Variable Name	Type	Width	Description
1	IMFLAG	Num	2	Not used in this analysis
2	ATPFLAG	Num	2	Not used in this analysis
3	ALTFLAG	Num	2	Altitude flag 1 - low altitude 2 - high altitude
4	STATE	Num	3	AEROS State code
5	SCENARIO	Num	5	Scenario flag 1 - I/M program and/or ATP in effect 0 - No program in effect
6	ASTM	Num	2	ASTM class - zero for all cases
7	YEAR	Num	3	Calendar year (2 digit format)
8	SPEED	Num	2	Vehicle speed index 1 - 15 mph 2 - 20 mph 3 - 25 mph 4 - 30 mph 5 - 35 mph 6 - 40 mph 7 - 45 mph 8 - 50 mph 9 - 60 mph
9	POL	Num	2	Pollutant index 1 - exhaust NMOG 2 - evaporative + running loss + resting loss NMOG 3 - exhaust CO 4 - exhaust NOx
10	LDGV	Num	9.3	Light-duty gasoline vehicle emission factor (grams/mile)
11	LDGT	Num	9.3	Light-duty gasoline truck emission factor (grams/mile)
12	HDGV	Num	9.3	Heavy-duty gasoline vehicle emission factor (grams/mile)
13	LDDV	Num	9.3	Light-duty diesel vehicle emission factor (grams/mile)
14	LDDT	Num	9.3	Light-duty diesel truck emission factor (grams/mile)
15	HDDV	Num	9.3	Heavy-duty diesel vehicle emission factor (grams/mile)
16	RVP_INUS	Num	5.1	RVP used in case (psi)
17	INUSE_YR	Num	5	2020 for all cases
18	TEMPAMP	Num	6.1	Ambient temperature (°F)
19	TEMPMEAN	Num	6.1	Mean temperature (°F) [(max + min)/2]
20	T_RANGE	Num	6.1	Temperature range (°F) (max - min)

Data Files:

File Type: ASCII Text

Inventory Year	Filename
1987	INT87EMF.DATA
1988	INT88EMF.DATA
1989	INT89EMF.DATA
1990	INT90EMF.DATA
1991	INT91EMF.DATA

Table IX.6

Highway Vehicles
File Structure

County-Level I/M Correspondence File

No.	Variable	Type	Length	Description
1	F_STATE	Num	2	FIPS State Code
2	F_COUNTY	Num	3	FIPS County Code
3	IM85	Num	1	0=No I/M; 1=I/M
4	IM86	Num	1	0=No I/M; 1=I/M
5	IM87	Num	1	0=No I/M; 1=I/M
6	IM88	Num	1	0=No I/M; 1=I/M
7	IM89	Num	1	0=No I/M; 1=I/M
8	IM90	Num	1	0=No I/M; 1=I/M
9	IM91	Num	1	0=No I/M; 1=I/M
10	ALTFLAG	Num	1	1=Low altitude; 2=High altitude

File Name: CNTYIM.DATA File Type: ASCII Text

Speed-SCC Correspondence File

No.	Variable	Type	Length	Description
1	AMSSCC	Char	10	AMS Source Category Code
2	SPEED	Num	2	Speed (mph)

File Name: SCCSPD.DATA File Type: ASCII Text

4. *Area Source - Solvents*

The file structure for the solvent inventories is shown in Table IX.7. The 1987 through 1990 Interim Inventory files allocated an incorrect length of four to the FIPS county code. The 1991 inventory was corrected to maintain consistency with the other files (length of 3 digits for the FIPS county code). The structure in Table IX.7 is consistent with this correction. It was recommended that the mainframe files be modified to delete the leading blank in the FIPS county code field in the 1987 through 1990 solvent inventory data files. These files will then be consistent with the structure shown in Table IX.7.

5. *Area Source*

The file structure for the area source inventories (non-solvent) is shown in Table IX.8. These files were also provided in ASCII text format.

Since these Inventory files were derived for the 1985 NAPAP, the Massachusetts emissions are by APCD. EPA will allocate these emissions to counties based on population and land use information from the AIRS GIS.

6. *AMS - NAPAP SCC Correspondence*

The file structure for the AMS - NAPAP SCC correspondence file is given in Table IX.9. This file is provided as a cross-reference to the NAPAP SCCs so that the temporal allocation factors developed for NAPAP can be applied.

B. CANADIAN INVENTORIES

1. *Point Sources*

The Canadian Point Source Files were provided in ASCII text format. The structure for the data files is shown in Table IX.10. The following FIPs codes were used to denote the three provinces in all Canadian Files:

Province	FIPs Code
New Brunswick	04
Ontario	08
Quebec	10

2. *Highway Vehicles*

Two files were provided for each inventory year for highway vehicles: province-level VMT estimates and province-level emission factors. Both files were provided in ASCII text format. The structure for the VMT and emission factor files is shown in Tables IX.11 and IX.12, respectively.

Table IX.7

Area Source - Solvents
File Structure

No.	Variable	Type	Length	Description
1	FIPST	Num	2	FIPS State Code
2	FIPSCNY	Num	4	FIPS County Code
3	SCC	Char	10	AMS Source Classification Code
4	EMISS1	Num	9.1	VOC emissions (tons per year)
5	EMF1	Num	11.9	VOC emission factor (lbs/SCC unit)
6	CONEFF1	Num	5.1	VOC control device efficiency
7	RULEFF1	Num	5.1	VOC rule effectiveness
8	PENETR1	Num	5.1	VOC penetration rate
9	OVRLEFF1	Num	5.1	VOC overall control efficiency
10	ACTIVITY	Num	9	Activity level

NOTES: Only VOC (pollutant 1) is included in the solvent Inventory data files since this is the only pollutant emitted by these categories.

Data Files: File Type: ASCII Text

Inventory Year	Filename
1987	INT87SV.DATA
1988	INT88SV.DATA
1989	INT89SV.DATA
1990	INT90SV.DATA
1991	INT91SV.DATA

Table IX.8

Area Source - Non-Solvents
File Structure

No.	Variable	Type	Length	Description
1	FIPST	Num	2	FIPS State Code
2	FIPSCNY	Num	4	FIPS County Code
3	SCC	Char	10	AMS Source Classification Code
4	SAROAD1	Num	5	SAROAD pollutant code 43104 (VOC)
5	SAROAD2	Num	5	SAROAD pollutant code 42603 (NO_x)
6	SAROAD3	Num	5	SAROAD pollutant code 42101 (CO)
7	SAROAD4	Num	5	SAROAD pollutant code 42401 (SO_2)
8	EMISS1	Num	9.1	VOC emissions (tons per year)
9	EMF1	Num	11.3	VOC emission factor (lbs/SCC unit)
10	CONEFF1	Num	5.1	VOC control device efficiency
11	RULEFF1	Num	5.1	VOC rule effectiveness
12	OVRLEFF1	Num	5.1	VOC overall control efficiency
13	EMISS2	Num	9.1	NO_x emissions (tons per year)
14	EMF2	Num	11.3	NO_x emission factor (lbs/SCC unit)
15	EMISS3	Num	9.1	CO emissions (tons per year)
16	EMF3	Num	11.3	CO emission factor (lbs/SCC unit)
17	EMISS4	Num	9.1	SO_2 emissions (tons per year)
18	EMF4	Num	11.3	SO_2 emission factor (lbs/SCC unit)

Data Files: File Type: ASCII Text

Inventory Year	Filename
1987	INT87AR.DATA
1988	INT88AR.DATA
1989	INT89AR.DATA
1990	INT90AR.DATA
1991	INT91AR.DATA

Table IX.9

AMS-NAPAP Correspondence
File Structure

No.	Variable	Type	Length	Description
1	NAPAPSCC	Char	3	NAPAP SCC
2	AMSSCC	Char	10	AMS SCC

File Name: AMSNAPSCC.DATA

File Type: ASCII Text

Table IX.10

Canadian Point Source File Structure

No	Variable Name	Type	Width	Description
1	PLANTID	Char	4	NAPAP Plant ID code
2	POINTID	Char	6	NAPAP Point ID code
3	STKHGT	Num	4.0	Stack Height (feet)
4	STKDIAM	Num	5.1	Stack Diameter (feet)
5	STKTEMP	Num	4.0	Stack Temperature (degrees F)
6	STKFLOW	Num	7.0	Flow Rate (ft^3/min)
7	HOURS	Num	2.0	Hours/Day in Operation
8	DAYS	Num	2.0	Days/Week in Operation
9	WEEKS	Num	2.0	Weeks/Year in Operation
10	THRUPUT	Num	9.0	Operating Rate (SCC units/yr)
11	HEATCON	Num	5.0	Fuel Heat Content (MMBtu/SCC unit)
12	SULFCON	Num	5.2	% Fuel Sulfur Content
13	ASHCON	Num	4.1	% Fuel Ash Content
14	STKVEL	Num	9.2	Stack Gas Velocity (feet/sec)
15	SCC	Char	8	Source Classification Code
16	AEROSPR	Num	2.0	AEROS Province Code
17	FIPST	Num	2.0	FIPS Province Code
18	SIC	Num	4.0	Standard Industrial Classification Code
19	LATC	Num	9.4	Latitude (degrees)
20	LONC	Num	9.4	Longitude (degrees)
21-24	SAROAD1 - SAROAD4	Char	5	SAROAD Pollutant Codes for VOC(=43104), NO_x(=42603), CO(=42101), and SO_2(=42401)
25-28	CONEFF1 - CONEFF4	Num	6.1	% Control Efficiency for VOC, NO_x, CO, and SO_2
29-32	CONPRI1 - CONPRI4	Num	3.0	Primary Control Equipment Codes for VOC, NO_x, CO, and SO_2
33-36	CONSEC1-CONSEC4	Num	3.0	Secondary Control Equipment Codes for VOC, NO_x, CO, and SO_2
37-40	ESTMET1-ESTMET4	Num	1.0	Estimation method for VOC, NO_x, CO, and SO_2
41-44	EMISS1 - EMISS4	Num	10.1	Emissions (tons per year) for VOC, NO_x, CO, and SO_2 (controlled with rule effectiveness)

Data Files:

File Type: ASCII Text

Inventory Year	Filename
1987	CAN87PT.DATA
1988	CAN88PT.DATA
1989	CAN89PT.DATA
1990	CAN90PT.DATA
1991	CAN91PT.DATA

Table IX.11

Canadian Highway Vehicle - VMT
File Structure

No	Variable Name	Type	Width	Description
1	PROVINCE	Char	2	FIPS Province Code
2	V_TYPE	Char	4	Vehicle Type
3	VMT	Num	9.3	Vehicle Miles Traveled (million miles/year)

Data Files: File Type: ASCII Text

Inventory Year	Filename
1987	CAN87VMT.DATA
1988	CAN88VMT.DATA
1989	CAN89VMT.DATA
1990	CAN90VMT.DATA
1991	CAN91VMT.DATA

Table IX.12

Canadian Highway Vehicle - Emission Factor File Structure

No	Variable Name	Type	Width	Description
1	IMFLAG	Num	2	Not used in this analysis
2	ATPFLAG	Num	2	Not used in this analysis
3	ALTFLAG	Num	2	Altitude flag 1 - low altitude 2 - high altitude
4	PROVINCE	Num	3	FIPS Province code
5	SCENARIO	Num	5	Scenario flag 1 - I/M program and/or ATP in effect 0 - No program in effect
6	ASTM	Num	2	ASTM class - zero for all cases
7	YEAR	Num	3	Calendar year (2 digit format)
8	SPEED	Num	2	Vehicle speed index 1 - 19.6 mph 2 - 55 mph
9	POL	Num	2	Pollutant index 1 - exhaust NMOG 2 - evaporative + running loss + resting loss NMOG 3 - exhaust CO 4 - exhaust NOx
10	LDGV	Num	9.3	Light-duty gasoline vehicle emission factor (grams/mile)
11	LDGT	Num	9.3	Light-duty gasoline truck emission factor (grams/mile)
12	HDGV	Num	9.3	Heavy-duty gasoline vehicle emission factor (grams/mile)
13	LDDV	Num	9.3	Light-duty diesel vehicle emission factor (grams/mile)
14	LDDT	Num	9.3	Light-duty diesel truck emission factor (grams/mile)
15	HDDV	Num	9.3	Heavy-duty diesel vehicle emission factor (grams/mile)
16	RVP_INUS	Num	5.1	RVP used in case (psi)
17	INUSE_YR	Num	5	2020 for all cases
18	TEMPAMP	Num	6.1	Ambient temperature (°F)
19	TEMPMEAN	Num	6.1	Mean temperature (°F) [(max + min)/2]
20	T_RANGE	Num	6.1	Temperature range (°F) (max - min)

Data Files:

File Type: ASCII Text

Inventory Year	Filename
1987	CAN87EMF.DATA
1988	CAN88EMF.DATA
1989	CAN89EMF.DATA
1990	CAN90EMF.DATA
1991	CAN91EMF.DATA

3. *Area Source*

The Canadian Area Source files were provided in ASCII Text format. The structure for the area source files is shown in Table IX.13.

Table IX.13

Canadian Area Source
File Structure

No.	Variable	Type	Length	Description
1	PROVINCE	Num	2	FIPS Province Code
2	SCC	Char	5	Source Classification Code
3	SAROAD1	Num	5	SAROAD pollutant code 43104 (VOC)
4	SAROAD2	Num	5	SAROAD pollutant code 42603 (NO_x)
5	SAROAD3	Num	5	SAROAD pollutant code 42101 (CO)
6	SAROAD4	Num	5	SAROAD pollutant code 42401 (SO_2)
7	EMISS1	Num	9.1	VOC emissions (tons per year)
8	EMISS2	Num	9.1	NO_x emissions (tons per year)
9	EMISS3	Num	9.1	CO emissions (tons per year)
10	EMISS4	Num	9.1	SO_2 emissions (tons per year)

Data Files: File Type: ASCII Text

Inventory Year	Filename
1987	CAN87AR.DATA
1988	CAN88AR.DATA
1989	CAN89AR.DATA
1990	CAN90AR.DATA
1991	CAN91AR.DATA

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APPENDIX A

STATE EMISSION SUMMARIES

Table A.1

State Emissions Summary - Fossil-Fuel Steam Utility Inventory VOC (tons per year)

State	1987	1988	1989	1990	1991
AL	727	704	772	773	833
AR	435	440	418	437	439
AZ	456	497	584	560	576
CA	475	556	578	418	321
CO	501	532	554	561	649
CT	272	323	334	263	239
DC	9	15	21	13	7
DE	134	158	143	110	118
FL	1,412	1,542	1,605	1,570	1,734
GA	955	926	902	978	872
IA	463	494	516	543	561
IL	1,069	970	933	997	1,027
IN	1,409	1,487	1,614	1,738	1,764
KS	534	529	526	547	545
KY	1,000	1,146	1,016	1,079	1,099
LA	529	606	588	600	610
MA	610	647	648	545	544
MD	367	415	496	423	417
ME	68	78	81	56	36
MI	1,108	1,096	1,097	1,067	1,069
MN	475	584	608	605	578
MO	811	861	868	851	862
MS	188	209	172	192	168
MT	264	361	358	330	359
NC	605	623	685	631	634
ND	612	759	722	756	776
NE	227	274	259	283	300
NH	93	108	110	99	86
NJ	244	273	295	193	176
NM	515	526	553	548	470
NV	251	307	287	278	297
NY	1,199	1,422	1,504	1,414	1,243
OH	1,667	1,725	1,777	1,707	1,583
OK	562	614	610	621	645
OR	0	0	11	30	64
PA	1,621	1,692	1,697	1,539	1,506
RI	16	23	13	9	3
SC	318	323	335	323	329
SD	30	85	82	82	90
TN	724	736	664	726	671
TX	3,493	3,631	3,787	3,712	3,735
UT	381	440	453	476	450
VA	360	362	436	312	346
VT	0	0	0	1	1
WA	191	195	196	171	181
WI	621	630	626	639	662
WV	1,069	1,111	1,136	1,050	969
WY	782	826	762	827	813
Total	**29,852**	**31,859**	**32,429**	**31,678**	**31,453**

Table A.2

State Emissions Summary - Fossil-Fuel Steam Utility Inventory NO_x (tons per year)

State	1987	1988	1989	1990	1991
AL	185,904	181,148	195,208	194,775	211,438
AR	79,999	81,165	77,761	82,309	82,427
AZ	97,776	107,989	127,058	120,170	122,416
CA	143,042	135,931	131,133	110,602	105,088
CO	115,091	119,654	128,160	129,008	135,446
CT	23,200	26,811	27,610	23,766	21,219
DC	485	840	1,166	704	390
DE	27,772	30,515	27,825	24,174	24,425
FL	311,889	321,518	332,962	322,800	342,739
GA	223,876	220,761	215,971	229,870	201,353
IA	100,469	106,076	111,377	121,443	124,927
IL	350,909	331,522	322,243	342,038	342,261
IN	436,347	479,776	495,083	507,649	505,138
KS	119,627	114,630	113,726	120,490	117,774
KY	300,165	354,837	313,776	330,777	339,551
LA	124,433	135,929	136,479	131,394	133,902
MA	83,312	83,519	90,063	79,574	77,553
MD	84,974	91,899	100,222	95,944	90,236
ME	4,431	5,120	5,368	3,701	2,398
MI	310,584	300,367	297,619	292,938	294,710
MN	132,629	147,227	156,883	155,530	149,175
MO	246,042	267,686	280,520	269,007	270,230
MS	50,240	52,799	44,989	50,650	44,685
MT	48,844	65,841	65,242	60,351	65,531
NC	155,727	163,791	177,536	161,590	164,931
ND	89,581	114,230	107,051	115,116	117,880
NE	59,032	75,291	73,655	78,140	82,157
NH	23,196	25,664	25,169	23,740	24,255
NJ	64,639	64,085	70,377	55,265	49,966
NM	98,161	125,907	119,773	115,439	99,420
NV	55,415	66,894	64,602	63,065	67,190
NY	147,966	167,356	184,164	185,955	170,365
OH	516,110	528,583	546,728	523,098	490,506
OK	126,169	134,717	137,565	139,311	143,721
OR	0	0	2,026	5,737	12,359
PA	379,468	397,432	399,240	375,315	368,894
RI	2,488	2,078	1,560	1,966	602
SC	79,339	80,704	83,872	81,934	81,896
SD	7,683	21,005	20,471	20,464	22,421
TN	194,774	197,299	176,744	192,154	179,308
TX	656,420	686,106	704,098	695,454	697,790
UT	81,315	93,835	93,943	99,840	94,433
VA	73,138	74,748	86,162	70,920	74,735
VT	35	6	37	189	301
WA	41,019	41,713	41,575	36,744	38,809
WI	153,193	158,833	155,508	157,297	164,619
WV	312,066	326,453	330,798	307,106	283,101
WY	153,539	161,748	150,228	161,905	159,048
Total	**7,072,512**	**7,472,036**	**7,551,323**	**7,467,403**	**7,393,717**

Table A.3

State Emissions Summary - Fossil-Fuel Steam Utility Inventory CO (tons per year)

State	1987	1988	1989	1990	1991
AL	6,266	6,064	6,655	6,681	7,194
AR	4,185	4,087	4,002	4,205	4,159
AZ	4,117	4,429	5,411	4,967	5,178
CA	12,386	11,471	11,175	9,419	8,836
CO	4,397	4,675	4,863	4,891	5,435
CT	1,966	2,211	2,311	1,873	1,702
DC	58	100	139	84	46
DE	1,236	1,338	1,264	1,009	1,066
FL	13,193	13,798	14,682	14,472	15,742
GA	8,201	7,959	7,748	8,411	7,494
IA	4,010	4,299	4,461	4,697	4,849
IL	9,118	8,342	8,064	8,641	8,922
IN	12,391	13,120	14,750	15,011	15,263
KS	4,783	4,765	4,748	5,029	5,188
KY	8,587	9,840	8,731	9,262	9,437
LA	7,995	8,587	8,352	8,804	8,675
MA	4,860	4,795	5,269	4,652	4,364
MD	3,162	3,433	4,180	3,652	3,582
ME	448	512	529	368	238
MI	9,611	9,445	9,434	9,246	9,253
MN	4,206	5,149	5,341	5,322	5,039
MO	6,956	7,390	7,457	7,340	7,564
MS	2,127	2,166	1,952	2,348	2,092
MT	2,274	3,104	3,073	2,836	3,078
NC	5,213	5,361	5,887	5,433	5,451
ND	5,808	6,753	6,422	6,674	6,848
NE	1,964	2,366	2,247	2,472	2,621
NH	727	870	884	776	655
NJ	2,661	2,561	2,813	2,010	2,001
NM	4,667	4,816	5,118	5,044	4,417
NV	2,221	2,733	2,735	2,684	2,818
NY	11,078	12,154	13,204	13,494	12,015
OH	14,322	14,861	15,245	14,664	13,627
OK	7,035	7,397	7,338	7,294	7,426
OR	0	0	93	256	551
PA	13,597	14,215	14,247	13,076	12,798
RI	183	155	115	144	44
SC	2,735	2,802	2,906	2,861	2,956
SD	261	730	706	707	774
TN	6,213	6,320	5,701	6,230	5,765
TX	44,253	45,089	46,127	45,322	45,525
UT	3,277	3,774	3,893	4,084	3,864
VA	2,993	2,990	3,598	2,650	2,888
VT	3	1	3	14	22
WA	1,642	1,670	1,672	1,468	1,553
WI	5,353	5,433	5,394	5,510	5,703
WV	9,192	9,547	9,765	9,030	8,327
WY	6,714	7,087	6,542	7,099	6,981
Total	**288,640**	**300,765**	**307,240**	**302,210**	**300,024**

Table A.4

State Emissions Summary - Fossil-Fuel Steam Utility Inventory
SO_2 (tons per year)

State	1987	1988	1989	1990	1991
AL	528,929	496,827	555,055	528,639	573,761
AR	66,992	72,089	67,293	69,160	71,068
AZ	88,537	97,850	119,910	120,366	122,295
CA	3,619	14,365	14,795	7,796	1,517
CO	72,673	84,520	82,426	87,617	85,668
CT	50,176	61,596	64,849	53,014	47,586
DC	1,837	2,986	4,019	2,524	1,398
DE	56,623	86,905	57,416	46,990	47,662
FL	690,843	710,885	689,985	645,930	709,106
GA	918,672	895,421	835,018	875,451	782,697
IA	197,375	196,232	188,393	180,539	193,259
IL	867,469	903,497	858,525	899,210	877,537
IN	1,462,968	1,459,752	1,519,510	1,511,021	1,513,091
KS	141,040	113,802	97,748	87,679	83,171
KY	709,279	767,385	899,913	915,361	888,915
LA	66,438	82,698	101,228	98,711	103,676
MA	248,356	262,436	265,595	232,286	238,075
MD	254,930	277,369	298,398	282,451	265,295
ME	13,761	14,590	15,066	11,502	7,474
MI	457,755	425,176	403,356	375,772	379,551
MN	79,551	86,645	85,788	84,468	80,691
MO	863,426	830,891	858,863	784,229	773,952
MS	115,076	131,219	107,953	119,115	100,827
MT	18,472	19,871	20,159	17,922	18,945
NC	311,360	320,387	351,341	336,450	332,015
ND	94,021	100,258	102,893	126,588	129,246
NE	41,673	49,910	47,036	50,625	53,478
NH	70,369	81,568	79,139	68,508	63,010
NJ	89,937	85,806	89,966	77,149	65,783
NM	52,850	44,960	72,011	64,104	53,981
NV	54,309	61,835	55,050	55,779	62,426
NY	391,290	386,201	423,637	416,770	394,065
OH	2,230,637	2,271,993	2,360,188	2,241,092	2,136,310
OK	86,214	93,904	92,541	101,852	107,118
OR	0	0	1,805	4,936	10,629
PA	1,263,074	1,262,937	1,227,632	1,213,386	1,187,109
RI	2,455	4,712	2,392	1,092	363
SC	175,616	161,978	159,716	167,417	165,694
SD	10,280	31,181	29,965	31,189	34,160
TN	821,042	852,382	762,029	796,526	755,842
TX	426,759	428,316	461,717	468,227	484,287
UT	24,089	26,246	30,472	32,051	30,978
VA	153,773	162,783	188,638	158,626	171,032
VT	25	4	14	0	0
WA	63,549	62,054	63,124	58,741	62,299
WI	297,033	298,431	285,997	284,855	306,275
WV	931,223	953,270	979,964	945,353	909,294
WY	94,854	100,172	94,280	84,596	82,011
Total	**15,661,225**	**15,936,292**	**16,172,805**	**15,823,662**	**15,564,621**

Table A.5

State Emissions Summary - Non-Utility Point Source Inventory
VOC (tons per year)

State	1987	1988	1989	1990	1991
AL	203,483	199,886	204,050	209,147	208,141
AR	37,061	37,209	37,715	37,284	37,442
AZ	1,636	1,717	1,778	1,689	1,670
CA	96,261	100,847	100,706	99,932	97,870
CO	5,479	5,574	5,613	5,412	5,339
CT	5,904	5,918	5,870	5,860	5,828
DC	9,246	10,984	10,109	13,425	13,108
DE	696	762	736	743	697
FL	19,790	20,630	20,556	20,157	19,791
GA	52,988	53,201	51,632	51,761	51,147
IA	9,428	10,094	10,398	10,544	10,382
ID	653	679	716	718	718
IL	313,525	326,084	325,108	333,208	331,422
IN	123,661	125,759	127,807	125,286	123,975
KS	31,637	30,922	30,576	30,259	30,390
KY	80,592	83,908	83,536	84,395	83,968
LA	134,558	137,463	139,124	142,468	143,907
MA	54,950	57,077	54,832	52,802	50,364
MD	22,740	23,317	22,940	22,823	21,669
ME	5,534	5,629	5,545	5,395	5,081
MI	132,930	127,930	122,671	114,199	109,279
MN	54,267	57,052	57,304	57,588	57,497
MO	125,577	131,875	139,183	137,495	132,455
MS	56,709	57,624	57,455	58,569	59,790
MT	6,409	6,223	5,972	5,814	5,959
NC	236,361	251,691	254,665	255,042	251,234
ND	954	1,062	865	878	903
NE	4,248	4,400	4,416	4,432	4,431
NH	4,758	4,845	4,787	4,637	4,432
NJ	147,923	150,609	150,716	152,948	149,696
NM	9,093	8,870	7,924	7,577	7,376
NV	254	283	311	333	334
NY	187,010	208,449	201,309	198,310	188,826
OH	125,890	124,979	123,414	122,551	119,374
OK	25,064	24,536	22,598	23,583	23,754
OR	40,339	41,460	42,222	44,197	45,155
PA	112,750	115,389	115,035	115,802	113,739
RI	10,041	10,397	10,263	9,713	9,558
SC	28,043	29,216	30,429	30,207	29,825
SD	5,638	7,188	7,311	7,708	7,821
TN	163,218	165,826	167,913	170,499	168,944
TX	2,161,845	2,325,030	2,264,344	2,270,556	2,335,715
UT	8,159	8,343	8,615	8,785	8,754
VA	153,761	157,344	152,713	147,928	144,505
VT	1,161	1,210	1,132	1,056	1,034
WA	61,961	65,066	67,072	70,323	67,748
WI	112,428	117,353	119,132	121,755	120,797
WV	136,573	146,972	147,385	145,586	138,764
WY	15,299	14,515	15,552	16,027	16,455
Total	**5,338,482**	**5,603,396**	**5,542,053**	**5,557,405**	**5,567,062**

Table A.6

State Emissions Summary - Non-Utility Point Source Inventory
NO_x (tons per year)

State	1987	1988	1989	1990	1991
AL	59,927	60,115	60,209	59,911	59,436
AR	21,924	22,007	21,910	21,902	22,006
AZ	3,790	3,851	3,581	3,301	3,229
CA	143,703	152,457	150,433	150,532	147,999
CO	16,291	16,738	16,430	16,665	16,483
CT	5,799	5,776	5,791	5,922	5,829
DC	10,474	10,957	10,944	10,951	10,978
DE	1,308	1,325	1,337	1,348	1,326
FL	43,735	44,212	44,295	43,062	42,317
GA	54,854	54,790	54,332	54,500	54,100
IA	21,622	21,703	22,151	22,372	22,003
ID	5,671	5,978	6,031	6,159	6,160
IL	136,706	140,131	135,004	137,653	134,937
IN	116,198	115,018	116,268	113,971	111,383
KS	84,580	87,891	87,450	86,882	85,879
KY	27,242	28,579	28,475	28,759	28,008
LA	217,415	223,256	220,570	224,907	225,995
MA	13,596	14,348	14,478	14,330	13,858
MD	24,191	24,673	25,224	25,558	24,414
ME	14,578	14,887	14,949	14,600	13,852
MI	70,826	71,437	69,869	67,455	65,219
MN	25,592	27,096	28,276	29,061	28,990
MO	37,407	37,652	37,238	37,319	35,498
MS	32,668	33,182	32,362	33,171	33,584
MT	11,788	11,401	11,260	11,167	11,222
NC	44,559	46,036	45,983	45,775	45,180
ND	9,264	9,562	8,962	9,077	9,124
NE	3,517	3,259	3,137	3,188	3,153
NH	2,436	2,439	2,453	2,419	2,356
NJ	45,549	47,392	46,690	46,551	45,730
NM	57,009	55,399	52,954	56,887	56,831
NV	1,411	1,643	1,740	1,760	1,701
NY	67,161	72,241	70,994	69,940	67,441
OH	83,380	84,409	83,090	82,703	80,174
OK	60,003	57,637	53,774	56,528	56,031
OR	8,274	8,331	8,233	7,889	7,906
PA	82,760	83,872	83,066	82,602	79,827
RI	1,014	980	1,000	991	964
SC	36,387	37,563	39,154	38,412	37,939
SD	1,332	1,327	1,498	1,539	1,625
TN	87,321	87,795	87,695	89,086	88,281
TX	581,689	609,472	600,766	608,818	624,252
UT	19,985	26,036	27,071	27,496	27,391
VA	64,227	64,757	63,369	61,673	60,401
VT	344	342	342	331	326
WA	33,654	34,605	35,442	36,473	34,762
WI	39,135	39,539	39,213	39,683	39,475
WV	56,415	57,544	56,702	55,863	52,908
WY	22,484	22,476	22,247	23,304	23,935
Total	**2,611,189**	**2,684,112**	**2,654,440**	**2,670,445**	**2,652,418**

Table A.7

State Emissions Summary - Non-Utility Point Source Inventory
CO (tons per year)

State	1987	1988	1989	1990	1991
AL	327,564	345,404	343,042	341,957	336,331
AR	97,150	98,025	101,451	99,742	101,089
AZ	5,676	6,229	4,991	4,769	4,664
CA	88,957	95,975	95,410	94,384	92,815
CO	15,238	14,937	14,760	13,064	13,327
CT	4,389	4,464	4,519	4,501	4,390
DC	75,163	80,017	78,838	76,371	77,395
DE	1,927	1,930	1,932	1,934	1,888
FL	63,993	64,570	65,392	61,814	61,011
GA	185,586	185,443	185,169	188,561	188,260
IA	6,288	6,401	6,468	6,416	6,264
ID	4,402	4,472	4,590	5,005	5,032
IL	248,949	262,099	254,834	252,026	243,243
IN	805,398	833,776	871,121	834,447	805,394
KS	121,109	116,471	112,851	110,351	111,977
KY	130,306	138,558	132,002	128,985	127,610
LA	690,719	725,262	746,326	761,985	769,759
MA	9,852	10,751	10,999	11,055	10,706
MD	25,567	26,062	25,963	26,673	25,745
ME	16,559	16,872	16,882	16,361	15,489
MI	360,600	354,368	332,013	304,660	288,683
MN	99,386	99,009	105,694	106,908	106,696
MO	130,317	135,568	139,649	137,988	132,496
MS	85,435	88,781	88,940	90,503	92,829
MT	46,168	45,411	47,172	45,493	44,753
NC	114,200	120,570	122,438	124,630	122,568
ND	1,379	1,452	1,284	1,298	1,311
NE	497	482	466	457	459
NH	15,257	15,394	15,517	15,351	14,936
NJ	14,929	16,956	16,751	16,539	16,079
NM	19,339	18,669	18,156	18,482	18,187
NV	61,423	62,275	64,341	59,686	57,730
NY	36,928	32,428	31,312	31,083	29,779
OH	920,797	965,775	947,186	931,499	890,409
OK	68,536	70,057	67,728	70,559	72,032
OR	23,285	23,836	24,783	24,053	23,929
PA	1,401,316	1,352,587	1,330,635	1,387,511	1,358,921
RI	62	64	64	63	62
SC	46,844	47,246	48,503	48,351	47,731
SD	3,880	4,392	4,568	4,613	4,876
TN	141,406	146,434	147,586	148,101	146,714
TX	774,626	824,371	805,020	810,374	834,311
UT	27,229	39,942	42,770	43,103	43,027
VA	67,670	71,120	72,228	74,225	72,316
VT	250	252	245	230	225
WA	375,587	405,930	426,123	437,754	422,375
WI	67,156	71,920	68,367	66,202	65,621
WV	325,856	337,531	330,898	324,617	312,985
WY	49,819	47,392	50,557	52,244	53,618
Total	**8,204,966**	**8,437,924**	**8,428,531**	**8,416,978**	**8,278,042**

Table A.8

State Emissions Summary - Non-Utility Point Source Inventory
SO_2 (tons per year)

State	1987	1988	1989	1990	1991
AL	149,534	150,098	150,969	151,733	149,889
AR	23,100	23,183	23,391	23,282	23,478
AZ	519,515	565,103	509,669	427,944	413,687
CA	68,893	72,772	71,447	71,075	70,343
CO	9,395	9,396	9,247	8,626	8,665
CT	10,734	10,832	10,855	11,167	11,123
DC	46,720	49,317	49,033	48,420	48,830
DE	3,051	3,123	3,173	3,226	3,186
FL	82,877	83,896	83,036	79,931	78,379
GA	91,599	91,340	90,712	91,204	90,754
IA	79,245	79,930	81,396	81,833	80,415
ID	22,995	24,266	24,352	24,725	25,072
IL	331,030	339,877	326,851	335,517	330,743
IN	310,893	306,306	308,786	303,297	298,136
KS	40,378	38,438	37,245	36,966	36,988
KY	63,189	66,204	65,477	65,764	64,854
LA	174,065	175,892	177,587	181,945	183,895
MA	29,061	29,926	29,621	29,022	28,021
MD	40,342	40,893	40,948	41,997	40,526
ME	56,440	57,726	58,135	56,717	53,813
MI	126,140	125,122	122,032	117,855	113,387
MN	37,599	39,391	41,396	42,482	42,366
MO	148,994	149,334	143,624	144,254	136,212
MS	56,784	59,135	58,613	59,700	61,355
MT	52,968	52,961	55,768	53,725	52,255
NC	97,996	102,284	102,831	102,122	100,942
ND	53,732	58,048	48,378	48,668	49,531
NE	5,852	5,824	5,942	6,191	6,106
NH	6,636	6,600	6,616	6,497	6,335
NJ	55,454	57,696	57,026	57,327	56,647
NM	148,969	175,982	175,669	180,546	177,505
NV	1,640	1,923	2,040	2,081	2,011
NY	162,545	176,520	173,339	170,319	163,857
OH	266,263	270,481	266,382	265,686	258,567
OK	34,723	32,820	28,133	29,656	30,204
OR	10,022	10,150	10,503	10,262	10,349
PA	160,763	163,266	162,058	160,466	155,794
RI	1,767	1,762	1,765	1,728	1,682
SC	77,073	78,418	80,536	78,453	77,383
SD	2,237	2,124	2,482	2,573	2,712
TN	153,282	156,187	156,835	157,487	156,211
TX	626,727	643,097	633,893	647,866	663,455
UT	20,272	24,696	26,053	26,358	26,367
VA	137,670	138,684	138,253	136,472	133,651
VT	1,100	1,081	1,108	1,099	1,083
WA	63,954	66,761	69,195	72,733	69,213
WI	118,280	119,676	118,779	120,189	119,760
WV	110,784	114,084	112,263	109,805	103,856
WY	37,255	36,609	36,429	39,227	40,305
Total	**4,930,533**	**5,089,232**	**4,989,867**	**4,926,219**	**4,859,900**

Table A.9

State Emissions Summary - Motor Vehicle Inventory
VOC (tons per year)

State	1987	1988	1989	1990	1991
AL	162,997	158,446	125,902	119,776	113,451
AR	69,456	67,879	60,753	54,725	50,646
AZ	106,749	98,640	90,181	84,375	80,700
CA	637,690	631,749	581,812	560,669	532,912
CO	92,252	84,563	68,946	62,907	57,426
CT	70,159	67,671	51,705	48,266	44,572
DC	10,677	10,288	7,854	7,355	6,948
DE	19,917	19,027	15,334	14,051	12,509
FL	368,041	379,299	304,980	300,193	287,691
GA	224,539	227,405	176,265	176,199	163,346
IA	67,464	65,814	59,074	55,160	52,815
ID	29,165	28,036	25,700	23,194	22,192
IL	265,694	256,281	217,988	193,501	181,914
IN	183,349	172,873	138,176	127,737	121,392
KS	65,474	65,485	49,028	52,595	49,725
KY	109,605	104,787	84,109	76,522	72,464
LA	153,738	162,131	117,220	105,789	96,108
MA	129,984	128,403	100,993	95,060	88,318
MD	127,128	119,546	95,856	84,735	78,346
ME	33,185	34,939	26,565	26,733	25,558
MI	261,085	249,492	215,057	202,202	191,964
MN	104,542	103,685	93,278	89,126	85,068
MO	154,404	147,120	108,900	118,793	110,677
MS	88,188	84,060	73,966	65,627	59,977
MT	24,191	23,866	21,591	19,513	18,761
NC	212,707	212,332	165,569	163,255	149,988
ND	20,780	19,430	17,283	16,069	14,980
NE	39,037	38,443	29,648	31,850	30,203
NH	27,382	13,212	10,700	21,316	20,371
NJ	176,724	157,268	126,843	117,553	108,523
NM	63,221	58,696	51,559	48,213	45,453
NV	27,558	27,810	26,246	25,548	24,931
NY	371,843	325,552	264,754	241,088	221,667
OH	291,757	276,085	195,714	214,107	201,281
OK	114,128	105,718	79,441	78,573	71,170
OR	71,098	69,959	62,706	59,527	56,458
PA	284,114	273,330	221,820	206,513	191,947
RI	22,137	21,636	16,667	15,787	14,635
SC	115,698	107,668	96,192	88,216	80,309
SD	21,867	21,276	18,968	17,503	16,441
TN	174,915	158,135	129,719	121,180	109,352
TX	586,953	555,137	455,210	413,460	381,058
UT	53,539	50,236	41,120	39,286	36,598
VA	174,081	167,707	132,361	121,636	114,635
VT	16,332	16,439	13,078	12,928	12,338
WA	125,669	114,296	109,158	106,840	103,712
WI	137,279	133,915	114,029	102,675	97,123
WV	48,053	46,458	37,128	34,084	31,916
WY	16,647	16,125	14,897	13,295	12,531
Total	**6,753,189**	**6,478,348**	**5,342,040**	**5,075,304**	**4,753,095**

Table A.10

State Emissions Summary - Motor Vehicle Inventory
NO_x (tons per year)

State	1987	1988	1989	1990	1991
AL	124,493	118,857	116,164	114,572	109,013
AR	78,117	78,214	74,704	74,300	70,348
AZ	121,653	121,218	117,256	116,586	111,046
CA	787,582	787,008	764,341	758,557	723,640
CO	85,708	84,710	79,455	77,482	72,322
CT	73,557	70,906	65,385	62,846	57,972
DC	7,705	7,574	6,837	6,868	6,527
DE	21,354	21,391	20,282	19,863	18,556
FL	325,112	322,658	308,512	308,597	294,950
GA	229,850	230,826	219,383	219,606	209,210
IA	87,063	86,386	83,165	80,206	74,717
ID	35,549	35,120	33,682	32,192	29,935
IL	269,205	272,501	258,280	248,583	232,499
IN	231,048	227,341	209,856	211,774	199,129
KS	75,248	77,141	71,042	70,157	66,042
KY	116,978	115,952	108,389	107,181	100,717
LA	151,077	148,228	136,515	130,256	118,939
MA	128,966	126,640	117,059	113,695	105,862
MD	123,766	120,799	114,231	110,621	103,407
ME	38,521	40,287	35,130	36,376	34,676
MI	271,680	270,156	253,758	249,878	235,174
MN	115,543	115,510	108,715	105,503	98,788
MO	175,765	172,583	161,655	158,588	148,188
MS	90,291	87,790	82,777	81,450	76,170
MT	33,295	32,675	30,463	29,350	27,156
NC	215,287	214,120	201,023	200,492	189,370
ND	24,303	23,097	21,716	20,681	18,969
NE	49,216	50,200	47,485	46,310	43,464
NH	29,493	14,283	13,409	27,727	26,513
NJ	165,168	157,783	150,210	146,016	136,630
NM	69,640	69,946	66,452	66,822	63,330
NV	30,708	32,187	32,007	32,676	32,155
NY	382,662	342,633	325,407	308,825	282,069
OH	302,953	291,036	242,587	269,044	250,799
OK	107,233	103,192	97,832	88,866	80,162
OR	94,096	95,298	90,030	88,900	83,967
PA	280,554	280,471	262,418	257,318	241,605
RI	21,147	20,613	18,698	18,348	17,050
SC	110,981	102,020	110,532	101,863	95,435
SD	26,962	26,757	25,337	23,979	22,090
TN	170,740	153,977	148,290	142,951	132,218
TX	553,751	541,954	501,822	479,575	440,605
UT	47,490	47,959	44,166	44,736	42,444
VA	176,467	172,475	162,927	162,348	154,006
VT	18,616	18,552	16,868	17,098	16,259
WA	143,857	137,087	138,349	138,428	133,754
WI	143,211	144,189	135,883	131,642	123,239
WV	56,456	55,505	51,968	50,674	47,237
WY	23,024	22,709	22,030	20,670	19,110
Total	**7,043,141**	**6,890,513**	**6,504,478**	**6,411,070**	**6,017,463**

Table A.11

State Emissions Summary - Motor Vehicle Inventory
CO (tons per year)

State	1987	1988	1989	1990	1991
AL	1,050,336	999,069	890,804	851,306	800,707
AR	485,540	474,739	437,035	411,062	380,880
AZ	776,150	717,189	663,864	622,662	571,327
CA	5,017,632	4,920,588	4,638,385	4,484,421	4,260,040
CO	1,029,093	933,747	790,362	715,282	636,107
CT	547,032	523,604	457,484	434,834	401,997
DC	83,249	81,327	68,953	67,688	64,229
DE	145,266	141,870	126,071	119,778	103,126
FL	2,724,709	2,699,287	2,364,623	2,308,485	2,181,609
GA	1,683,196	1,673,107	1,455,498	1,444,360	1,343,976
IA	596,612	582,828	542,501	508,544	475,113
ID	253,864	245,874	228,730	210,697	195,514
IL	2,284,144	2,190,848	1,956,448	1,800,452	1,675,259
IN	1,462,559	1,403,710	1,221,808	1,174,626	1,096,098
KS	572,507	575,925	503,291	485,526	451,294
KY	833,028	806,903	705,925	665,736	619,570
LA	1,084,764	1,073,528	885,490	807,509	726,854
MA	1,111,406	1,084,386	948,061	917,773	852,614
MD	974,508	924,442	815,585	758,466	697,872
ME	305,891	318,359	265,431	269,117	254,636
MI	2,287,029	2,232,692	2,023,926	1,960,058	1,840,652
MN	1,025,070	1,019,195	939,649	899,881	844,952
MO	1,305,669	1,253,685	1,090,829	1,064,285	983,204
MS	597,253	568,162	513,731	475,790	434,949
MT	238,109	231,210	210,170	195,916	180,406
NC	1,545,442	1,518,790	1,322,024	1,288,828	1,193,929
ND	193,179	181,180	165,539	153,795	140,614
NE	339,184	338,514	302,494	290,424	270,490
NH	249,459	119,348	107,238	212,456	200,635
NJ	1,207,123	1,137,517	1,032,944	988,495	926,782
NM	686,737	634,786	557,281	512,809	465,829
NV	289,621	287,980	272,128	259,216	247,558
NY	3,064,690	2,713,956	2,444,733	2,267,002	2,067,394
OH	2,399,395	2,282,741	1,774,607	1,959,635	1,822,429
OK	857,182	804,442	717,520	637,962	567,331
OR	569,401	563,994	514,820	498,488	466,410
PA	2,265,290	2,222,100	1,973,974	1,879,186	1,750,779
RI	183,814	178,855	154,261	149,167	138,393
SC	823,424	751,414	752,455	677,287	619,909
SD	207,364	202,695	185,664	171,034	156,897
TN	1,313,288	1,163,090	1,042,538	971,743	879,059
TX	4,217,521	3,991,389	3,466,050	3,182,523	2,859,335
UT	579,592	538,334	454,224	428,927	387,544
VA	1,366,719	1,316,914	1,151,388	1,079,734	1,009,176
VT	155,612	154,593	134,675	133,971	126,457
WA	1,063,445	987,050	963,595	934,895	901,103
WI	1,148,320	1,137,939	1,029,970	970,019	906,889
WV	368,110	356,489	314,344	294,424	271,300
WY	147,347	143,128	134,934	123,019	112,996
Total	**53,715,870**	**51,403,511**	**45,714,050**	**43,719,293**	**40,562,222**

Table A.12

State Emission Summary - Solvent Inventory
VOC (tons per year)

State	1987	1988	1989	1990	1991
AL	79,458	83,043	83,159	83,855	85,218
AR	55,662	59,723	58,700	58,932	61,208
AZ	58,820	62,514	63,006	63,068	65,036
CA	483,053	507,910	516,898	525,441	534,646
CO	62,793	65,384	65,668	66,221	67,342
CT	62,744	65,120	64,499	64,032	64,591
DC	9,545	9,840	9,642	9,391	9,274
DE	11,320	12,009	12,176	12,236	12,439
FL	186,775	197,701	199,817	202,559	207,103
GA	115,780	120,362	120,747	120,320	123,257
IA	80,730	79,745	80,009	81,573	76,998
ID	18,244	19,538	20,247	20,705	20,358
IL	228,435	233,547	235,957	234,850	227,678
IN	142,387	145,039	149,002	147,381	143,538
KS	65,970	70,260	61,298	65,967	64,372
KY	64,923	67,480	67,653	68,091	68,706
LA	65,442	70,477	67,330	67,421	67,488
MA	121,999	126,871	125,508	123,456	122,920
MD	71,462	74,658	75,066	76,076	76,452
ME	21,960	23,440	23,762	23,880	23,601
MI	186,649	192,381	195,248	192,614	191,716
MN	102,820	104,816	108,960	108,339	107,791
MO	103,447	108,275	108,332	107,759	106,975
MS	62,708	68,139	65,113	65,539	68,255
MT	19,482	15,912	19,959	18,076	21,891
NC	160,262	168,913	168,995	169,870	172,149
ND	35,046	15,710	25,946	30,056	34,067
NE	43,192	47,892	43,919	44,698	44,867
NH	21,088	22,143	22,192	21,882	21,988
NJ	138,077	143,298	142,169	139,232	139,212
NM	21,906	22,788	23,011	23,202	23,880
NV	14,477	15,490	16,157	17,274	17,880
NY	307,424	316,396	313,244	309,836	308,176
OH	223,195	230,150	230,174	229,304	226,358
OK	58,137	59,984	59,286	59,880	59,306
OR	47,556	50,265	50,536	52,031	52,993
PA	209,348	216,760	218,099	216,453	216,619
RI	21,391	22,090	22,122	21,436	21,265
SC	65,807	69,318	70,010	70,215	71,647
SD	20,751	19,268	20,274	21,878	23,355
TN	106,334	111,295	111,801	111,129	112,700
TX	296,630	306,660	306,249	314,456	322,302
UT	30,063	31,196	31,054	31,979	32,513
VA	112,373	116,444	116,733	118,064	119,169
VT	10,771	11,571	11,753	11,843	11,944
WA	76,578	80,896	83,446	86,549	88,118
WI	109,641	113,874	116,658	117,070	117,650
WV	29,995	30,382	29,761	29,603	29,228
WY	7,832	8,328	7,899	8,132	9,345
Total	**4,650,479**	**4,815,295**	**4,839,246**	**4,863,848**	**4,895,583**

Table A.13

State Emissions Summary - Area Source Inventory
VOC (tons per year)

State	1987	1988	1989	1990	1991
AL	149,738	151,040	149,647	148,161	146,613
AR	73,144	74,347	73,953	73,493	72,344
AZ	67,071	67,986	67,347	67,379	67,555
CA	492,519	497,521	496,686	492,039	484,704
CO	58,142	57,694	56,288	56,323	56,132
CT	43,996	43,812	42,630	42,038	41,590
DC	6,732	6,608	6,320	6,098	5,971
DE	46,637	52,279	54,789	70,463	71,083
FL	234,034	239,912	240,222	239,618	240,029
GA	238,572	241,470	238,134	235,092	234,100
IA	59,818	58,986	58,854	58,543	55,804
ID	121,105	121,068	121,479	121,558	120,677
IL	176,889	179,269	176,017	175,893	173,075
IN	140,394	141,529	139,462	138,573	136,379
KS	61,163	61,856	58,745	60,508	58,577
KY	76,449	76,938	75,339	75,389	74,510
LA	300,727	318,299	309,268	314,257	309,195
MA	69,665	69,780	67,776	66,352	65,660
MD	61,927	63,033	61,640	61,468	60,070
ME	29,955	30,332	29,522	29,484	29,029
MI	178,085	178,419	174,335	170,561	166,795
MN	102,702	102,601	101,635	100,842	99,324
MO	106,152	106,046	104,106	102,484	100,432
MS	95,628	97,713	94,777	93,195	92,441
MT	95,177	91,334	95,377	93,593	95,190
NC	199,134	201,181	198,017	195,195	192,855
ND	26,345	24,474	25,061	25,210	24,902
NE	35,025	36,227	35,507	35,929	34,798
NH	18,364	18,616	18,294	18,250	18,308
NJ	179,638	181,732	179,373	172,983	171,743
NM	38,257	38,980	38,563	38,696	38,518
NV	24,268	25,366	26,367	27,229	27,452
NY	191,192	187,333	182,523	179,625	175,050
OH	222,372	221,706	217,311	212,825	207,548
OK	100,502	99,329	96,277	96,032	93,771
OR	88,468	89,671	89,322	89,262	87,904
PA	268,957	271,873	266,554	262,359	256,797
RI	11,786	11,800	11,370	11,139	10,882
SC	480,221	491,121	493,765	486,300	479,541
SD	42,469	41,779	41,635	41,566	41,145
TN	132,448	129,834	127,693	124,548	122,957
TX	888,304	916,518	906,366	913,011	917,023
UT	33,927	34,499	34,102	34,249	34,343
VA	163,717	160,870	158,791	154,897	153,524
VT	12,867	12,979	12,731	12,667	12,542
WA	160,648	161,021	163,426	164,493	165,170
WI	95,981	96,284	95,118	94,225	92,539
WV	379,820	389,100	384,855	376,884	355,680
WY	17,342	17,506	17,180	17,139	17,225
Total	**6,898,471**	**6,989,668**	**6,914,549**	**6,878,113**	**6,789,491**

Table A.14

State Emissions Summary - Area Source Inventory
NO_x (tons per year)

State	1987	1988	1989	1990	1991
AL	85,382	95,054	96,937	98,321	100,798
AR	77,941	93,814	101,366	95,613	94,562
AZ	66,313	75,173	70,904	75,482	81,346
CA	422,624	430,768	443,008	441,901	426,008
CO	65,185	68,801	73,854	73,307	76,212
CT	19,242	20,247	20,294	20,554	21,105
DC	9,352	9,124	8,991	9,075	8,837
DE	5,673	5,826	5,724	5,720	5,644
FL	108,079	113,680	111,475	110,241	108,804
GA	82,978	85,856	84,818	85,036	84,474
IA	73,811	72,262	73,963	76,802	68,053
ID	51,033	51,995	55,214	55,943	53,690
IL	154,506	161,785	165,704	164,113	161,529
IN	125,663	131,540	133,161	134,558	136,033
KS	127,504	128,987	121,709	126,363	123,687
KY	114,215	119,832	124,119	122,487	124,157
LA	228,600	229,590	236,961	240,624	245,933
MA	55,347	55,745	55,367	55,394	56,582
MD	81,469	83,375	82,883	80,237	73,014
ME	12,037	13,585	12,826	13,075	12,886
MI	99,718	112,835	114,064	111,324	110,115
MN	69,446	68,740	74,453	73,075	68,135
MO	76,284	78,043	77,950	74,724	72,291
MS	78,360	87,733	89,020	91,437	102,523
MT	117,739	97,238	123,886	113,875	125,834
NC	74,078	76,153	76,453	77,687	77,390
ND	41,801	31,395	37,966	40,878	41,130
NE	71,346	76,088	74,358	76,208	72,804
NH	9,577	9,578	9,869	10,839	11,967
NJ	72,998	75,671	75,985	76,869	78,175
NM	40,850	39,442	41,607	40,810	41,581
NV	23,553	25,690	28,041	28,650	28,864
NY	121,613	124,191	119,085	119,827	119,765
OH	132,587	142,018	141,527	143,220	141,121
OK	124,559	120,886	122,732	126,252	124,921
OR	73,369	78,019	80,044	81,512	82,335
PA	130,099	133,014	136,563	136,019	136,345
RI	6,424	10,250	6,529	7,948	9,399
SC	37,157	38,650	38,935	39,838	39,716
SD	26,179	22,517	26,136	28,056	26,333
TN	66,450	68,983	68,792	67,734	67,873
TX	775,906	823,139	844,703	871,984	907,356
UT	32,174	35,191	36,564	36,206	39,835
VA	90,569	93,504	93,691	94,001	93,827
VT	5,821	6,102	6,255	5,909	5,635
WA	79,904	82,787	85,189	85,977	87,813
WI	67,737	69,809	74,933	72,847	70,440
WV	33,634	34,757	35,716	36,734	37,621
WY	75,799	76,553	76,167	78,096	81,505
Total	**4,622,683**	**4,786,016**	**4,896,492**	**4,933,379**	**4,966,002**

Table A.15

State Emissions Summary - Area Source Inventory
CO (tons per year)

State	1987	1988	1989	1990	1991
AL	362,719	357,925	345,337	335,136	327,990
AR	227,776	224,265	217,892	209,499	203,512
AZ	244,953	244,756	241,189	238,159	239,483
CA	1,772,974	1,761,852	1,749,756	1,723,734	1,699,935
CO	238,455	232,154	225,664	219,605	216,074
CT	188,453	183,510	176,671	169,425	166,095
DC	38,323	36,672	35,195	32,869	32,041
DE	47,727	46,802	45,596	44,218	43,477
FL	834,321	842,116	835,400	816,573	816,404
GA	586,174	586,198	584,477	565,778	564,028
IA	173,918	168,138	162,614	157,405	149,282
ID	828,331	825,249	823,259	820,834	816,192
IL	620,500	603,033	582,364	559,527	542,916
IN	442,435	431,952	416,618	401,963	391,254
KS	167,964	164,505	150,889	154,485	142,089
KY	335,615	327,000	313,027	302,157	293,235
LA	435,565	516,109	460,244	457,426	405,542
MA	320,529	312,511	301,612	289,151	283,612
MD	200,480	199,877	189,527	185,987	181,022
ME	154,825	151,598	147,392	141,880	138,408
MI	703,332	684,682	660,070	634,309	617,588
MN	432,302	422,994	411,436	397,365	386,964
MO	454,544	441,374	425,256	408,400	397,986
MS	295,149	298,892	280,661	270,241	265,549
MT	571,511	560,751	566,361	559,248	559,662
NC	656,745	649,586	636,491	620,862	608,144
ND	50,973	46,655	47,204	45,648	44,400
NE	92,693	92,206	88,238	85,801	82,200
NH	94,693	93,778	91,643	88,039	88,183
NJ	336,463	328,552	317,143	305,545	298,948
NM	152,401	149,904	146,392	143,055	141,146
NV	65,668	66,502	68,044	69,327	69,449
NY	780,959	758,734	729,746	700,261	681,128
OH	717,097	697,995	672,261	645,756	627,244
OK	246,787	236,752	227,138	218,971	209,561
OR	581,096	579,590	572,350	564,877	550,273
PA	785,377	760,127	732,607	704,998	685,968
RI	47,420	46,682	44,521	42,955	42,375
SC	350,837	345,138	336,747	329,946	325,081
SD	222,493	218,759	216,536	213,445	210,887
TN	504,434	493,281	477,118	460,508	450,699
TX	777,615	767,228	750,011	739,376	727,381
UT	144,450	143,869	142,002	138,400	137,028
VA	477,465	469,473	454,976	442,053	435,421
VT	68,876	67,687	65,814	63,425	62,312
WA	963,797	958,967	952,420	945,874	938,652
WI	420,950	410,772	398,651	384,292	373,581
WV	179,326	170,746	162,804	155,122	148,936
WY	68,953	67,157	65,159	63,873	62,998
Total	**19,466,445**	**19,245,052**	**18,744,524**	**18,267,780**	**17,882,331**

Table A.16

State Emissions Summary - Area Source Inventory
SO_2 (tons per year)

State	1987	1988	1989	1990	1991
AL	36,810	49,052	53,760	58,665	63,445
AR	19,541	15,132	22,479	17,983	16,785
AZ	8,458	7,741	8,727	6,531	5,924
CA	98,813	103,318	105,222	108,195	109,068
CO	7,390	6,916	6,344	6,322	6,274
CT	11,149	11,699	12,579	13,172	14,000
DC	3,559	1,783	1,496	1,405	1,459
DE	3,073	2,760	2,624	3,291	3,856
FL	25,870	26,179	21,882	22,368	22,606
GA	9,919	9,570	7,464	6,997	6,763
IA	10,392	12,430	11,548	12,694	13,109
ID	10,122	10,039	10,601	10,718	10,551
IL	16,902	16,772	14,912	14,674	14,303
IN	145,199	156,756	149,254	155,165	158,725
KS	7,156	7,284	6,932	7,073	6,826
KY	38,211	38,659	40,109	38,033	37,551
LA	134,904	132,785	130,040	115,825	115,131
MA	35,532	33,871	30,889	30,739	31,044
MD	64,500	54,167	49,797	45,866	43,079
ME	8,619	14,400	10,839	11,611	12,053
MI	12,672	14,318	12,863	12,540	11,972
MN	9,005	9,925	10,383	10,007	9,428
MO	35,951	35,908	33,878	33,918	33,984
MS	10,881	22,963	46,723	70,415	135,747
MT	9,708	7,725	10,393	9,193	10,057
NC	36,686	37,616	35,810	37,297	37,527
ND	19,707	18,261	20,059	20,621	21,184
NE	6,787	7,806	7,508	8,821	9,646
NH	4,475	3,974	4,339	4,851	5,280
NJ	36,183	37,801	35,380	36,031	36,243
NM	8,674	8,235	13,009	8,099	7,453
NV	3,797	4,034	4,579	4,870	5,227
NY	77,580	77,433	64,099	65,751	66,492
OH	77,147	80,232	71,282	74,463	73,696
OK	15,640	15,783	16,787	14,619	13,621
OR	24,934	25,693	24,930	25,256	25,054
PA	47,837	46,269	47,832	48,017	48,713
RI	3,938	3,819	3,154	3,388	3,374
SC	9,326	9,634	8,397	8,574	8,493
SD	4,556	4,125	4,720	4,836	4,756
TN	15,314	16,212	16,114	15,502	15,479
TX	168,799	135,635	121,018	96,334	86,584
UT	13,294	12,085	14,353	14,149	24,087
VA	41,406	38,749	34,930	36,894	37,429
VT	3,147	3,282	3,474	3,321	3,330
WA	20,221	21,058	20,583	20,465	20,485
WI	10,208	11,349	11,768	10,815	9,982
WV	5,948	6,448	6,392	6,714	7,017
WY	16,898	18,103	15,454	15,290	15,414
Total	**1,446,835**	**1,445,783**	**1,417,710**	**1,408,376**	**1,480,304**

APPENDIX B

PETROLEUM REFINERY VOC EMISSIONS

APPENDIX B
PETROLEUM REFINERY VOC EMISSIONS

The 1985 NAPAP petroleum refinery VOC emissions are a combination of point and area source emissions. Originally, this category was covered only by the point source SCCs. The national emission estimate from NAPAP was well below that estimated in *Trends*, so the area source category Petroleum Refinery Fugitives was created to reconcile this discrepancy. *Trends* estimates, allocated to the county level using refinery capacity statistics, were used as the basis for developing adjusted estimates. Point source estimates at the county level were subtracted from this total and the resulting emissions were inventoried under the area source category. County point source emissions from process heaters and catalytic cracking units were not included in the point source total for petroleum refineries. Where negative emissions resulted for the area source category, zero was used for that county and emissions in other counties were lowered so that national totals matched *Trends*. A comparison of the *Trends* and NAPAP emission estimates are shown in Table B.1.

While estimates for all of the categories differ, the largest magnitude of difference occurs with blowdown systems. *Trends* estimates 426 thousand tons, compared with 8.7 thousand tons, which was reported in the NAPAP Point Source Inventory.

Emission differences can be the result of different assumptions concerning any of the following: emission factors, level of control, or activity levels. Table B.1 shows the NAPAP and *Trends* control levels. The NAPAP estimate is a combination of two SCCs: 30600401 (blowdown systems with vapor recovery with flaring) and 30600402 (blowdown systems without controls).

Table B.2 shows the emissions from the 1985 NAPAP for blowdown systems. Uncontrolled and controlled emissions are shown.

The NAPAP uncontrolled emissions were calculated based on the controlled emissions and the control device efficiency reported. Many of the sources reported emissions of zero and control efficiency of 100 percent. Uncontrolled emissions cannot be back-calculated for these processes unless the emission factor and operating rate are used. Uncontrolled emissions were estimated for these processes using the operating rate and Federal emission factor. There are 129 total blowdown sources in NAPAP. Of these, 21 sources reported control efficiencies of 100 percent. Eight of these sources have no operating rate reported, so uncontrolled emissions could not be estimated. These were not included in the summary statistics in Table B.2. This indicates that the average efficiency for blowdown sources is even higher than the 90 percent calculated above. It is also possible that, since emissions are zero (or near zero) for many blowdown sources, these would not be included in the inventory at all. (The general NEDS rule is that all sources emitting

Table B.1

Comparison of Trends and NAPAP - Petroleum Refinery Emissions

Process	1985 Trends 1,000 tons	1985 Trends % Control	1985 NAPAP 1,000 tons	1985 NAPAP % Control
Refinery Operations				
FCC	8.4	91.0	32.3	95.6
TCC	0.1	71.9	1.4	25.9
Process Heaters				
Oil	0.1	0.0	2.7	0.0
Gas	2.5	0.0	4.7	60.1
Compressors	0.7	0.0	3.0	2.8
Blowdown Systems	426.0	47.0	8.8	89.6
Process Drains	158.6	70.0	45.5	49.4
Vacuum Jets	28.6	43.0	11.3	61.6
Cooling Towers	27.8	0.0	9.6	17.4
Asphalt Blowing	13.8	0.0	2.0	83.8
Miscellaneous	161.7	0.0	80.1	88.7
Area Source			727.8	45.0
Total	828.2		929.2	

Table B.2

1985 NAPAP Blowdown Emissions

Source Category	Uncontrolled	Controlled	% Control
Blowdown			
Vapor Recovery/Flaring	23,682	7,851	67
Without Controls*	60,802	906	99
TOTAL	84,484	8,757	90

NOTES: * The SCC description (30600402) for this category is blowdown systems without controls; however, primary control devices and efficiencies were listed for these sources.

more than 25 tpy of a criteria pollutant should be included in a facility's inventory, which results in an increase in the average efficiency.) Of the 129 blowdown sources reported in the inventory, 109 are with vapor recovery and flares, while 20 sources are without control. This again indicates that blowdown systems are well controlled.

If the *Trends* emissions estimate for blowdown is adjusted to 90 percent control, emissions decrease to 80 thousand tons. The control level reported in *Trends* is 47 percent.

The second area where the *Trends* and NAPAP estimates for blowdown emissions could differ is in the emission factor used. Table B.3 is a comparison of the *Trends* and NAPAP emission factors for each process.

The uncontrolled emission rate for the *Trends* blowdown category is based on a 1970 snapshot of emissions, operating rate, and control efficiencies. *Trends* estimates emissions based on the following factors:

Old Systems (1970 rates):	178.84 lb/10^3 bbl
New Systems (NSPS rate):	5.26 lb/10^3 bbl

(Old systems would then be operating at an average efficiency of 32 percent over uncontrolled, NSPS systems at 98 percent control.)

The calculation for the NSPS capacity is fairly complicated. The calculation starts with 1977 capacity. Each successive year, any increase in capacity from the previous year is considered NSPS capacity plus an additional 1 percent of the previous year's capacity (to account for retirement). In 1985, 75.8 percent of capacity is categorized as "old" and 24.2 percent "new." This results in the weighted emission factor of 136.8 lbs/10_3 bbl. The *Trends* control efficiency is calculated based on this weighted emission factor and the estimated uncontrolled emission factor of 290 lb/10_3 bbl.

Table B.3

Comparison of NAPAP and *Trends* Emission Factors

Process	Trends (lbs/1,000 bbl)	NAPAP (lbs/1,000 bbl refinery feed)	
Refinery Operations			
FCC	140.8	140.8	lbs/1,000 bbl fresh feed
TCC	55.7	55.7	lbs/1,000 bbl fresh feed
Process Heaters			
Oil	12.6	0.3	lbs/1,000 gal
Gas	2.8	2.8	lbs/10^6 cf
Compressors	0.2	3.7	
Blowdown Systems	290	0.8	(vapor recovery)
		580	(no control)
Process Drains	190	200	
Vacuum Jets	42.8	18	
Cooling Towers	10	10	
Asphalt Towers	5	60	lbs/ton asphalt
Miscellaneous	58.3		

There has been no attempt to update the emission factors used in *Trends*, primarily to maintain consistency with past estimation methodologies. With the advances in control technology and application of reasonably available control technology (RACT), existing sources are most likely operating at a higher efficiency than assumed in *Trends*.

As a comparison to the NAPAP and *Trends* estimates, a weighted average emission factor based on AP-42 was calculated. The factors were weighted by the number of sources appearing in NAPAP under each SCC. Operating rate would be a more accurate indication of the weighting, however, since this variable does not have a high level of confidence within the NAPAP Inventory. The weighted factor is estimated based on 109 sources at 0.8 lbs/1,000 bbl and 20 sources at 580 lbs/1,000 bbl. This results in a weighted factor of 90.6 lbs/1,000 bbl. Multiplying this by the 1985 activity level from *Trends* (5549.4 million bbl) and applying the NAPAP efficiency of 90 percent yields total blowdown emissions of 25,000 tons per year.

As a lower bound for blowdown emissions, assume that all systems have a vapor recovery system and flare. Using the emission factor of 0.8 lbs/1,000 bbl, the lower bound estimate of national blowdown emissions is 2.2 thousand tons.

As yet another comparison, the Control Techniques Guideline (CTG) for petroleum refinery processes, published in 1977 (Group I summary document), was reviewed. This was after a review of the 1970 snapshot of emissions from which the emission factors were derived for *Trends*. This comparison further indicated that the control level in *Trends* is underestimation, because existing sources in nonattainment areas must apply RACT according to the CTG. The uncontrolled emission rate quoted in this source is 301 lbs/1,000 bbl (close to that used in *Trends*). The CTG recommends venting all vapors to a flare or a vapor recovery system with an average reduction of 98 percent (or 6 lbs/1,000 bbl). Using this controlled emission factor, nationwide emissions are estimated at 17,000 tons.

It is not entirely clear why the AP-42 emission factors differ from those in the CTG. One guess is that the CTG factor is for process unit turnarounds which may only include planned releases. AP-42 accounts for both planned and accidental releases. For the controlled rate, AP-42 assumes complete combustion or smokeless burning (required in most States). This is accomplished by injecting steam into the combustion zone of the flare to provide turbulence and to aspirate air. This is probably more stringent than the control recommended by the CTG.

The summary of VOC control techniques (published by EPA in 1986) lists the uncontrolled emission factor for process unit turnarounds at 300 lbs/1,000 bbl. The emission factor for refineries that control process unit turnarounds by depressurizing to a control device is listed at 5.26 lbs/1,000 bbls. These again match *Trends*. Using the controlled emission factor of 5.26 lbs/1,000 bbls yields national emissions of 14.6 thousand tons.

A summary of alternative estimates of blowdown emissions is shown in Table B.4. From the information presented, it is clear that blowdown emissions are well controlled. Of the alternatives listed in Table B.4, the AP-42 emission factor weighted by the number of sources was chosen for use in the inventory. The emission factors from the CTG and *Trends* are from earlier documents. The AP-42 section on petroleum refineries was

Table B.4

Alternative Estimates of National VOC Emissions
Petroleum Refinery Blowdown Systems

Methodology	VOC Emissions (thousand tpy)
Trends	426
Trends, 90 percent Efficiency	80
AP-42 emission factor, weighted by number of sources reported in NAPAP with vapor recovery and flares, and without	25
CTG emission factor, with vapor recovery	17
NAPAP Point Source Inventory	8.7
AP-42 emission factor, with vapor recovery systems and flaring	2.2

completed in 1980, the other factors date back to the 1970s. In addition, there are probably blowdown systems not included in the inventory because they are well controlled and have zero or near zero emissions. While weighting by throughput would be more accurate, this is simply not available.

APPENDIX C

INDUSTRIAL FUEL CONSUMPTION -- NATURAL GAS

APPENDIX C
INDUSTRIAL FUEL CONSUMPTION -- NATURAL GAS

Industrial natural gas combustion is included in both the point and area source portions of the 1985 NAPAP Emissions Inventory. There is concern about the high estimate of area source NO_x emissions for this category. Area source fuel combustion NO_x emissions are not controlled in future years under the ROM scenarios because only small sources are supposed to be represented by this category. This category would then be expected to have an even larger share of total emissions in future years.

A. NAPAP INVENTORY METHODS

Area source emission estimates for this category were developed by estimating area source industrial natural gas fuel consumption and combining this with emission factors for the process. The emission factors are based on AP-42 emission factors for natural gas boilers (10 to 100 MMBtu) and internal combustion engines. These represent two use subcategories: boilers, and gas pipelines and plants. The emission factors were weighted according to the point source consumption for the two categories.

The methodology for determining area source fuel consumption consisted of two steps. First, county industrial fuel consumption is calculated, summed, and then normalized by State published values. The county-level fuel use is calculated by adjusting county area source employment figures for SICs 20 through 39 by a fuel intensity factor. The fuel intensity ratio is determined by dividing the State consumption of fuel for each SIC category by the respective State employment. County area source consumption is then summed for all counties. The resulting State-level consumption is normalized by published State values. Total State sales of NG and LPG are found in the *Natural Gas Annual* and API *Sales of Natural Gas Liquids and Liquefied Refinery Gases.* Fuel consumption by SIC used in the fuel intensity ratio calculations is obtained from the *Annual Survey of Manufacturers*. The area source and point source fuel consumption are then compared to the total published fuel consumption to verify the values.

Table C.1 shows the natural gas throughput from NAPAP (point source) industrial natural gas fuel consumption estimates. It is obvious from this table that the NAPAP throughput is not a reliable statistic, especially in Texas where external combustion estimates appear to be off by orders of magnitude (or presented in other units) and the internal combustion throughput values are simply missing.

Table C.1

Comparison of SEDS and NAPAP Fuel Consumption Values

Area	1985 Natural Gas Consumption (billion cubic feet) NAPAP - External Combustion	NAPAP - Internal Combustion	NAPAP Area	NAPAP - Total	SEDS Industrial
U.S. Total	607,735	521	3,046	611,302	6,876
U.S. - non-Texas	3,441	521	2,465	6,427	5,135
Texas	604,294	0	581	604,875	1,732
California	1,914	92	173	2,179	433
New York	20	0	73	93	101
Illinois	323	6	141	470	285
Pennsylvania	22	17	192	231	231

A comparison of the NAPAP emissions with the 1985 *Trends* values (EPA, 1986) is shown in Table C.2. These estimates are in good agreement. The emission factor for gas pipelines and plants is based on the SCC for internal combustion. These emission factors are higher than those for external combustion. The NAPAP emission factor for area sources is weighted according to the contribution of external versus internal point source combustion. This may tend to favor external combustion, hence lowering emission estimates.

Table C.2

Comparison of Industrial Natural Gas Emission Estimates

Source Category	NO_x Emissions (thousand tons) 1985 NAPAP	1985 Trends
Boilers	272.3	333.3
Gas Pipelines and Plants	644.7	1,894.6
Area Source	1176.9	----
Total	2093.9	2,227.9

In the NAPAP effort, the point source fuel consumption estimates underwent extensive QA prior to estimating the area source fuel consumption (Kimbrough, 1992). The area source documentation, however, does not adequately document the procedures used to estimate the area source consumption. First, total natural gas consumption for a State was calculated as the total of industrial natural gas use, pipeline fuel, and lease and plant fuel. Chemical feedstock use of natural gas was then subtracted. Liquified petroleum gas is also included.

The calculation of area source fuel consumption was reviewed during the NAPAP Inventory process for all States. This review led to overriding the calculated value for many areas. State totals were compared to published values and the area or point source consumption adjusted so that the numbers were "rationalized." The NEDS methodology for stationary source fuel use typically either underestimated or overestimated so badly that external adjustments were applied.

Table C.3 shows point and area source industrial natural gas NO_x emissions by State, along with each State's contribution to national emissions. Table C.4 shows industrial natural gas consumption by State from the *Natural Gas Annual,* along with each State's contribution to national consumption. Comparison of these tables should show the same general trends -- higher contribution of natural gas should lead to higher emissions. (This does not include LPG or the subtraction of chemical feedstock.) The true relationship between consumption and emissions depends on the mix of processes and the degree of control in the State. Texas and Louisiana show the highest emissions and also the highest consumption. While Texas shows 25.0 percent of total consumption, its share of emissions is 35.8 percent. The opposite is true for Louisiana, which has 13.8 percent of consumption and 11.1 percent of emissions.

The last remaining factor in developing the area source emissions is the emission factor. Table C.5 is a listing of the NAPAP area source emission factor for each State. There is a large variation among States. Texas has one of the highest NO_x emission factors at 1,601 lbs/MMcf.

As stated earlier, the NO_x emission factors used in NAPAP are based on the AP-42 factors for natural gas boilers (10 to 100 MMBtu) and internal combustion. Turbines are not included in the weighting. The individual factors for the three processes are:

NG boilers (10 to 100 MMBtu):	140 lbs/MMcf
Internal combustion engines:	3,400 lbs/MMcf
Turbines:	300 lbs/MMcf

These factors were weighted according to the point source fuel consumption for each of the two categories reported in NEDS. (It is unclear from the documentation whether NAPAP used consumption that was represented only by the SCCs listed above, or by all boiler, engine, and turbine SCCs.) To compare these emission factors, the NAPAP throughput for all industrial natural gas SCCs within the NAPAP Inventory were classified into the categories above. Table C.6 shows the weighted NO_x emission factors calculated using this procedure. A comparison of these factors to those in Table C.5 *does not match up at all.*

Finally, the AMS documentation for calculating area source fuel consumption and emissions was reviewed for comparison to the NAPAP methodology. The AMS methodology separates calculation of emissions from boilers versus internal combustion and also separately accounts for LPG. This method will more accurately account for the fraction of fuel consumption for external versus internal combustion.

Due to the time constraints of this analysis, no changes were made to the NO_x emissions from industrial natural gas combustion. Further investigation of this category is recommended, but would require accessing (if they still exist) the files that were used to calculate industrial area source fuel consumption and emission factors for the 1985 NAPAP Inventory. Without reliable point source fuel consumption estimates, it is impossible to make any corrections or adjustments to the area source data. One possibility is to develop a new weighting of the emission factors based on the industrial fuel consumption minus chemical feedstock (boilers) versus turbines and engines (lease and plant fuel and pipeline). The AMS employs these distinctions.

Table C.3

1985 NAPAP Industrial Natural Gas NO_x Emissions

State	NO_x Emissions (tpy) Area Source	Point Source	Total	Percent of National
Alabama	22,022	9,003	31,025	1.5
Arizona	23,678	208	23,886	1.1
Arkansas	24,612	2,417	27,029	1.3
California	39,235	73,975	113,210	5.4
Colorado	18,211	10,773	28,984	1.4
Connecticut	1,349	505	1,854	0.1
Delaware	901	186	1,087	0.1
Washington, DC	475	0	475	0.0
Florida	11,567	5,347	16,914	0.8
Georgia	7,561	7,846	15,407	0.7
Idaho	4,232	445	4,677	0.2
Illinois	21,517	29,527	51,044	2.4
Indiana	8,989	16,167	25,156	1.2
Iowa	11,573	2,307	13,880	0.7
Kansas	44,907	65,210	110,117	5.3
Kentucky	37,064	4,804	41,868	2.0
Louisiana	96,461	135,653	232,114	11.1
Maine	87	16	103	0.0
Maryland	3,807	2,801	6,608	0.3
Massachusetts	2,889	2,470	5,359	0.3
Michigan	25,989	14,304	40,293	1.9
Minnesota	3,786	4,507	8,293	0.4
Mississippi	26,633	13,029	39,662	1.9
Missouri	7,205	930	8,135	0.4
Montana	4,651	739	5,390	0.3
Nebraska	4,741	2,611	7,352	0.4
Nevada	599	45	644	0.0
New Hampshire	912	69	981	0.0
New Jersey	2,428	3,929	6,357	0.3
New Mexico	19,360	69,378	88,738	4.2
New York	10,684	3,097	13,781	0.7
North Carolina	11,145	380	11,525	0.6
North Dakota	3,522	5,085	8,607	0.4
Ohio	19,068	9,924	28,992	1.4
Oklahoma	62,884	48,248	111,132	5.3
Oregon	7,661	1,077	8,738	0.4
Pennsylvania	37,438	22,464	59,902	2.9
Rhode Island	525	0	525	0.0
South Carolina	5,055	1,585	6,640	0.3
South Dakota	616	0	616	0.0
Tennessee	0	14,136	14,136	0.7
Texas	464,860	283,846	748,706	35.8
Utah	8,961	10,322	19,283	0.9
Vermont	67	0	67	0.0
Virginia	6,997	1,930	8,927	0.4
Washington	4,835	2,727	7,562	0.4
West Virginia	4,545	19,150	23,695	1.1
Wisconsin	8,458	3,119	11,577	0.6
Wyoming	42,089	9,340	51,429	2.5
National	**1,176,851**	**915,631**	**2,092,482**	

Table C.4

1985 Industrial Natural Gas Consumption (million cubic feet)

State	Lease & Plant	Pipeline	Industrial	Total	Percent of National
Alabama	5,476	11,078	132,281	148,835	2.0
Arizona	6	18,542	16,503	35,051	0.5
Arkansas	12,439	8,203	96,660	117,302	1.6
California	25,274	14,406	407,585	447,265	6.1
Colorado	10,829	7,137	36,934	54,900	0.8
Connecticut	0	351	18,937	19,288	0.3
Delaware	0	5	21,600	21,605	0.3
Washington, DC	0	376	0	376	0.0
Florida	7,174	3,866	68,776	79,816	1.1
Georgia	0	5,359	140,009	145,368	2.0
Idaho	0	2,951	19,461	22,412	0.3
Illinois	4,237	11,188	280,638	296,063	4.1
Indiana	11	4,823	211,115	215,949	3.0
Iowa	0	10,350	87,060	97,410	1.3
Kansas	42,457	38,110	118,847	199,414	2.7
Kentucky	9,095	14,313	54,137	77,545	1.1
Louisiana	258,069	42,290	710,060	1,010,419	13.8
Maine	0	11	856	867	0.0
Maryland	1	2,248	54,684	56,933	0.8
Massachusetts	0	1,381	33,157	34,538	0.5
Michigan	8,195	10,544	181,583	200,322	2.7
Minnesota	0	6,237	66,301	72,538	1.0
Mississippi	6,296	25,309	99,174	130,779	1.8
Missouri	0	4,264	65,702	69,966	1.0
Montana	2,138	2,248	8,220	12,606	0.2
Nebraska	87	5,552	33,134	38,773	0.5
Nevada	0	113	6,173	6,286	0.1
New Hampshire	0	84	892	976	0.0
New Jersey	0	2,248	81,242	83,490	1.1
New Mexico	46,709	25,966	11,635	84,310	1.2
New York	1,041	3,549	99,829	104,419	1.4
North Carolina	0	4,744	74,808	79,552	1.1
North Dakota	4,710	704	2,209	7,623	0.1
Ohio	5,442	8,281	247,792	261,515	3.6
Oklahoma	88,185	25,316	156,317	269,818	3.7
Oregon	120	4,585	37,776	42,481	0.6
Pennsylvania	4,575	33,005	226,299	263,879	3.6
Rhode Island	0	141	4,619	4,760	0.1
South Carolina	0	2,244	63,038	65,282	0.9
South Dakota	93	228	3,511	3,832	0.1
Tennessee	138	10,186	97,109	107,433	1.5
Texas	307,759	92,040	1,423,876	1,823,675	25.0
Utah	9,001	1,201	37,448	47,650	0.7
Vermont	0	5	1,867	1,872	0.0
Virginia	443	4,426	50,334	55,203	0.8
Washington	0	2,887	63,176	66,063	0.9
West Virginia	7,190	17,760	38,122	63,072	0.9
Wisconsin	0	2,794	115,267	118,061	1.6
Wyoming	108,917	4,968	18,861	132,746	1.8
National	**976,107**	**498,617**	**5,825,614**	**7,300,338**	

SOURCE: *1985 Natural Gas Annual.*

Table C.5

NAPAP Area Source Industrial Natural Gas Fuel Consumption

State	NO_x Emissions (tons)	NO_x Emission Factor (lbs/MMcf)	Calculated Consumption (MMcf)
Alabama	22,022	524	84,055
Arizona	23,678	1,613	29,360
Arkansas	24,612	797	61,761
California	39,235	454	172,841
Colorado	18,211	853	42,692
Connecticut	1,349	170	15,871
Delaware	901	141	12,780
Washington, DC	475	2,500	380
Florida	11,567	463	49,963
Georgia	7,561	359	42,114
Idaho	4,232	546	15,499
Illinois	21,517	306	140,635
Indiana	8,989	140	128,410
Iowa	11,573	538	43,021
Kansas	44,907	992	90,530
Kentucky	37,064	1,077	68,823
Louisiana	96,461	976	197,661
Maine	87	187	929
Maryland	3,807	306	24,884
Massachusetts	2,889	234	24,691
Michigan	25,989	351	148,085
Minnesota	3,786	374	20,248
Mississippi	26,633	649	82,072
Missouri	7,205	387	37,242
Montana	4,651	1,130	8,239
Nebraska	4,741	447	21,213
Nevada	599	183	6,548
New Hampshire	912	2,500	730
New Jersey	2,428	140	34,686
New Mexico	19,360	1,866	20,748
New York	10,684	291	73,430
North Carolina	11,145	292	76,336
North Dakota	3,522	1,617	4,364
Ohio	19,068	512	74,483
Oklahoma	62,884	1,193	105,416
Oregon	7,661	476	32,185
Pennsylvania	37,438	390	191,990
Rhode Island	525	797	4,915
South Carolina	5,055	302	33,475
South Dakota	616	381	3,223
Tennessee	0	0	0
Texas	464,860	1,601	580,724
Utah	8,961	449	39,914
Vermont	67	155	865
Virginia	6,997	452	30,965
Washington	4,835	220	43,952
West Virginia	4,545	2,500	3,640
Wisconsin	8,458	222	76,189
Wyoming	42,089	1,954	43,079

Table C.6

Throughput and Calculated Emission Factors

State	Boiler	Engines	Turbines	Total	Weighted NO_x Emission Factor (lbs/MMcf)
	1985 NAPAP Throughput (million cubic feet)				
Alabama	51,806	1,768	0	53,574	248
Arizona	519	0	29	548	148
Arkansas	11,140	1,132	0	12,272	441
California	1,914,248	44,100	48,359	2,006,707	215
Colorado	3,194	8,202	740	12,136	2,353
Connecticut	2,041	149	0	2,190	362
Delaware	1,894	0	0	1,894	140
Florida	12,188	1,819	3,525	17,532	510
Georgia	57,687	349	0	58,036	160
Idaho	4,844	0	0	4,844	140
Illinois	322,761	3,029	2,544	328,334	171
Indiana	28,741	7,391	67	36,199	806
Iowa	19,112	82	0	19,194	154
Kansas	34,588	37,346	7,552	79,486	1,687
Kentucky	11,561	2,235	0	13,796	668
Louisiana	258,142	55,655	105,720	419,517	613
Maine	230	0	0	230	140
Maryland	11,931	0	0	11,931	140
Massachusetts	9,947	197	223	10,367	205
Michigan	18,323	6,110	0	24,433	955
Minnesota	13,248	1,617	1,350	16,215	478
Mississippi	22,747	5,638	4,237	32,622	724
Missouri	8,882	130	85	9,097	188
Montana	2,545	255	0	2,800	437
Nebraska	3,663	1,276	0	4,939	982
Nevada	1,469	0	0	1,469	140
New Hampshire	221	0	0	221	140
New Jersey	44,283	0	0	44,283	140
New Mexico	7,303	41,285	21,363	69,951	2,113
New York	20,366	0	0	20,366	140
North Carolina	4,566	0	0	4,566	140
North Dakota	708	3,140	0	3,848	2,800
Ohio	22,987	4,208	0	27,195	644
Oklahoma	30,181	38,562	3,545	72,288	1,887
Oregon	7,929	0	0	7,929	140
Pennsylvania	21,507	11,312	6,077	38,896	1,113
South Carolina	19,430	0	0	19,430	140
South Dakota	0	0	0	0	0
Tennessee	29,485	6,432	5,151	41,068	671
Texas	604,294,608	0	3	604,294,611	140
Utah	23,769	5,477	794	30,040	739
Virginia	17,368	0	0	17,368	140
Washington	286,673	0	1,300	287,973	141
West Virginia	40,736	8,890	3,640	53,266	695
Wisconsin	24,574	215	0	24,789	168
Wyoming	6,178	5,707	1,159	13,044	1,581