United States
Environmental Protection
Agency
Research and Development

Air and Energy Engineering
Research Laboratory
Research Triangle Park NC 27711
EPA/600/S7-89/012 Feb. 1992

EPA

Project Summary

The 1985 NAPAP Emissions Inventory (Version 2): Development of the Annual Data and Modelers' Tapes

Mark Saeger

This report documents the development of the 1985 National Acid Precipitation Assessment Program (NAPAP) Emissions Inventory (Version 2). The 1985 annual inventory and related modelers' inventory represent the most comprehensive and highest quality emissions data available. The inventory spans the 48 contiguous U.S. states, the District of Columbia, and 10 Canadian provinces. Emissions data are included for 9,175 plants and area source categories from 3,073 counties in the U.S. and the 10 Canadian provinces. Eleven pollutant species are included in the annual inventory, and the emissions data have been disaggregated into an additional 49 species classes for use in modeling applications. Emissions of SO_2, NO_x, and VOC included in the inventory are 27.2, 22.6, and 24.5 million tons/year, respectively. Summaries of emissions data are presented at various levels of aggregation including nation, EPA regions, state/province, and process categories. Emissions data are also analyzed by plant size, stack height, and general source type, and emissions variations are examined on seasonal and daily bases. The report presents information on the development of the inventory data including improvements that have been made since the development of the 1980 NAPAP Emissions Inventory and quality assurance activities.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The 1985 NAPAP Emissions Inventory (Version 2) has been developed by the NAPAP Task Group on Emissions and Controls. It is a second generation inventory of emissions and facility data covering the U.S. and Canada. The first detailed annual and modelers' inventories were developed by NAPAP to represent emissions from the base year 1980. The 1980 inventory development effort led to the identification of several methodological improvements that were incorporated into the 1985 effort. The 1985 NAPAP Emissions Inventory (Version 1) was completed in November 1988. The Version 1 inventory included only anthropogenic emissions data for the U.S. and was used to develop and test software to convert the data into formats required by regional atmospheric models. This report documents the development of the 1985 (Version 2) inventory and summarizes the emissions data included in the inventory.

The emissions inventory was developed in two phases. Phase 1 involved data collection and quality assurance of source characteristics and emissions totals on an annual basis. The annual inventory has been designated the 1985 NAPAP Emissions Inventory (Version 2). Phase 2 involved the generation of a modelers' inventory that was based on statistical representations of the spatial and temporal distribution of annual emissions and on representative chemical and physical speciation profiles for particular source types. The geographic coverage of the inventory ex-

Printed on Recycled Paper

tends over the contiguous 48 states, the District of Columbia, and the 10 Canadian provinces.

Annual Emissions Inventory

The annual point and area source emissions data for the U.S. were collected through the existing EPA emissions inventory data system known as the National Emissions Data System (NEDS). Annual emissions estimates for natural sources of alkaline particulates for the U.S. were developed primarily for application to the NAPAP inventory development. Environment Canada provided estimates of annual emissions for Canadian sources. The total emissions for the 11 pollutant groups included in the annual inventory are presented in Table 1.

The annual inventory was developed to provide information for assessing acid deposition problems. The annual inventory provides a data base that can be used to determine the relative contributions of acid deposition precursor emissions from various industries and activities within various geopolitical regions. The combined U.S. and Canadian point source inventory includes positive emissions for 9,175 plants encompassing 66,308 emission points and 77,852 process-level emissions records. Area source emissions are reported for 97 emissions categories for the 3,073 counties in the U.S. and the District of Columbia and for 129 emissions categories in 10 Canadian provinces. Particulate emissions are reported for unpaved roads and wind erosion in the U.S. and Canada and for dust devils in the U.S.

Table 1. *1985 NAPAP Emissions Inventory Data Summaries*

	Emissions Magnitude, 10^3 TPY	
Pollutant	*U.S.*	*Canada*
SO_2	23,146	4,059
NO_x	20,541	2,081
VOC	22,072	2,453
THC	24,851	2,763
TSP	8,383	2,022
CO	60,938	11,919
SO_4	490	100
NH_3	1,685	213
HCl	693	12
HF	108	5
TSP (natural)	50,253	29,528

Modelers' Emissions Inventory

NAPAP requires emissions data suitable for use as input to the Regional Acid Deposition Model (RADM) that is used to study source-receptor relationships. RADM, an event-specific analysis tool, requires daily inputs of meteorological and emissions data to simulate specific deposition events. The modelers' inventory was constructed to represent a typical weekday, Saturday, and Sunday for each of the four seasons, giving a total of 12 temporal scenarios. Each of the 12 scenarios is resolved to a regular grid pattern defined by dimensions of 1/6° latitude and 1/4° longitude, that covers the entire contiguous U.S. and Canada to the border between the Canadian provinces and the northern territories at 60° north latitude.

The annual emissions estimates were further resolved into species or species classes to provide the level of species resolution required to simulate the chemical processes of interest. The resulting modelers' inventory includes emissions estimates for 49 chemical species and particulate size classes in addition to the 10 species included in the annual inventory. The 59 species included in the modelers' inventory are listed in Table 2.

Emissions Summary

The distribution of SO_2, NO_x, VOC, and TSP emissions among point and area sources, by country, is shown in Figure 1. Emissions of SO_2 result primarily from point sources; NO_x emissions are nearly evenly split between point and area sources; and VOC emissions result primarily from area sources. Natural sources of particulate represent the bulk of the TSP emissions.

The spatial distribution of the annual SO_2 emissions is represented in Figure 2. The grid scale represented on these maps is 1° longitude by 2/3° latitude. Thus, these grids represent emissions sums for 16 contiguous inventory grid cells. The SO_2 emissions map shows that SO_2 emissions result from a small number of large sources concentrated in a relatively few locations. Similar maps for the other annual pollutants are shown in the report. SO_2 is shown here as an example. The NO_x and VOC emissions are more evenly distributed than SO_2 as a result of the importance of area sources on emissions of those pollutants.

Table 2. *Species Included in the Modelers' Inventory*

SO_2	Alkanes, 0.25-0.5 reactivity[a]
NO_x	Alkanes, 0.5-1.0 reactivity[a]
NO	Alkanes, 1.0-2.0 reactivity[a]
NO_2	Alkanes, >2.0 reactivity[a]
SO_4	Alkane/aromatic mix
CO	Ethene
HCl	Propene
HF	Alkenes, primary
NH_3	Alkenes, internal
TSP	Alkenes, primary/internal mix
TSP, 0.0-2.5 μm	Benzene, halobenzene
TSP, 2.5-6.0 μm	Aromatics, <2.0 reactivity[a]
TSP, 6.0-10.0 μm	Aromatics, >2.0 reactivity[a]
Calcium, 0.0-2.5 μm	Phenols and cresols
Calcium, 2.5-10.0 μm	Styrenes
Calcium, total	Formaldehyde
Magnesium, 0.0-2.5 μm	Higher aldehydes
Magnesium, 2.5-10.0 μm	Acetone
Magnesium, total	Higher ketones
Potassium, 0.0-2.5 μm	Organic acids
Potassium, 2.5-10.0 μm	Acetylene
Potassium, total	Haloalkenes
Sodium, 0.0-2.5 μm	Unreactive
Sodium, 2.5-10.0 μm	Others, <0.25 reactivity[a]
Sodium, total	Others, 0.25-0.5 reactivity[a]
VOC	Others, 0.5-1.0 reactivity[a]
THC	Others, >1.0 reactivity[a]
Methane	Unidentified
Ethane	Unassigned
Propane	

[a]*Reactivity is defined in terms of the rate constant range for the reaction with OH^{-1}, in units of 10^4 ppm^{-1} min^{-1}.*

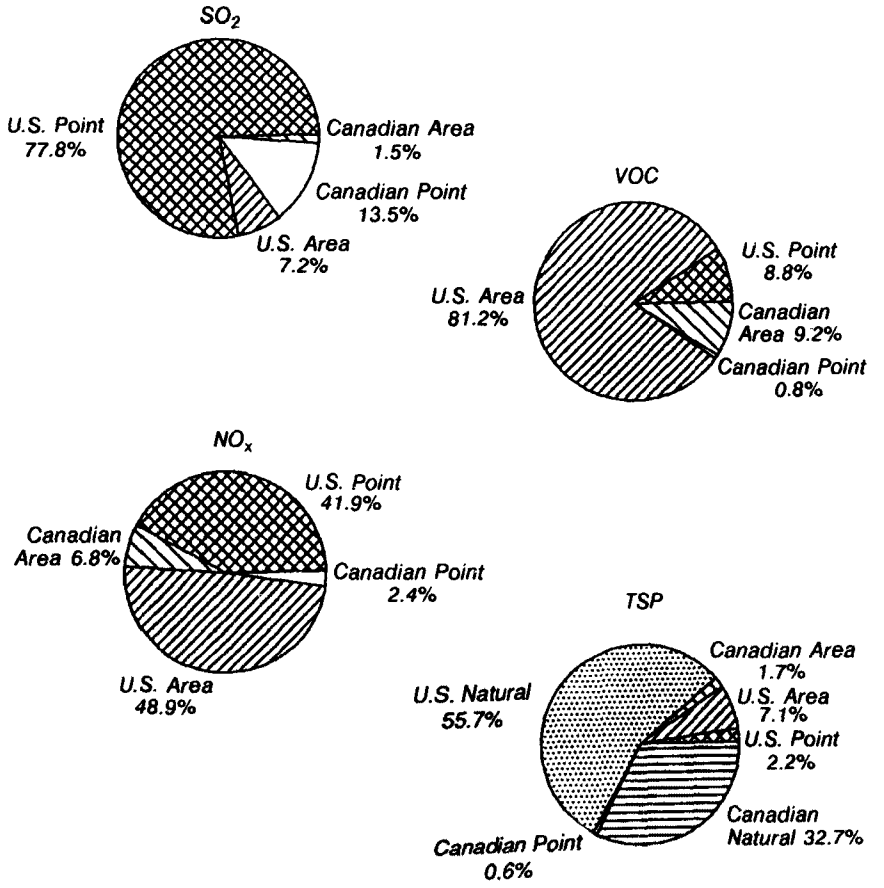


Figure 1. *1985 NAPAP Emissions Inventory—distribution of emissions by source category for SO_2, NO_x, VOC, and TSP.*

Table 3. *1985 NAPAP Emissions Inventory (Version 2)—Point and Area Source Emissions by Major Category*

	Emissions (10^3 tons/yr)		
	SO_2	NO_x	VOC
U.S. Sources			
Electric utilities	16,055	6,662	40
Industrial combustion	2,679	3,198	97
Commercial/residential/other combustion	613	790	1,862
Industrial/manufacturing processes	2,931	926	3,715
Transportation	864	8,835	8,800
Other	4	130	7,558
U.S. Total:	23,146	20,541	22,072
Canadian Sources			
Electric utilities	819	270	3
Industrial combustion	340	272	5
Commercial/residential/other combustion	69	81	88
Industrial/manufacturing processes	2,731	84	510
Transportation	99	1,323	1,125
Other	0	51	722
Canadian total:	4,058	2,081	2,453

The distribution of the emissions of SO_2, NO_x, and VOC is represented for major source category groupings by country in Table 3. The SO_2 emissions result primarily from utilities, industrial combustion, and smelters (included in the industrial/manufacturing process category) in both countries. NO_x emissions result primarily from the utilities, industrial combustion, and transportation sectors, and VOC emissions result primarily from transportation and solvent use (included in the "other" category).

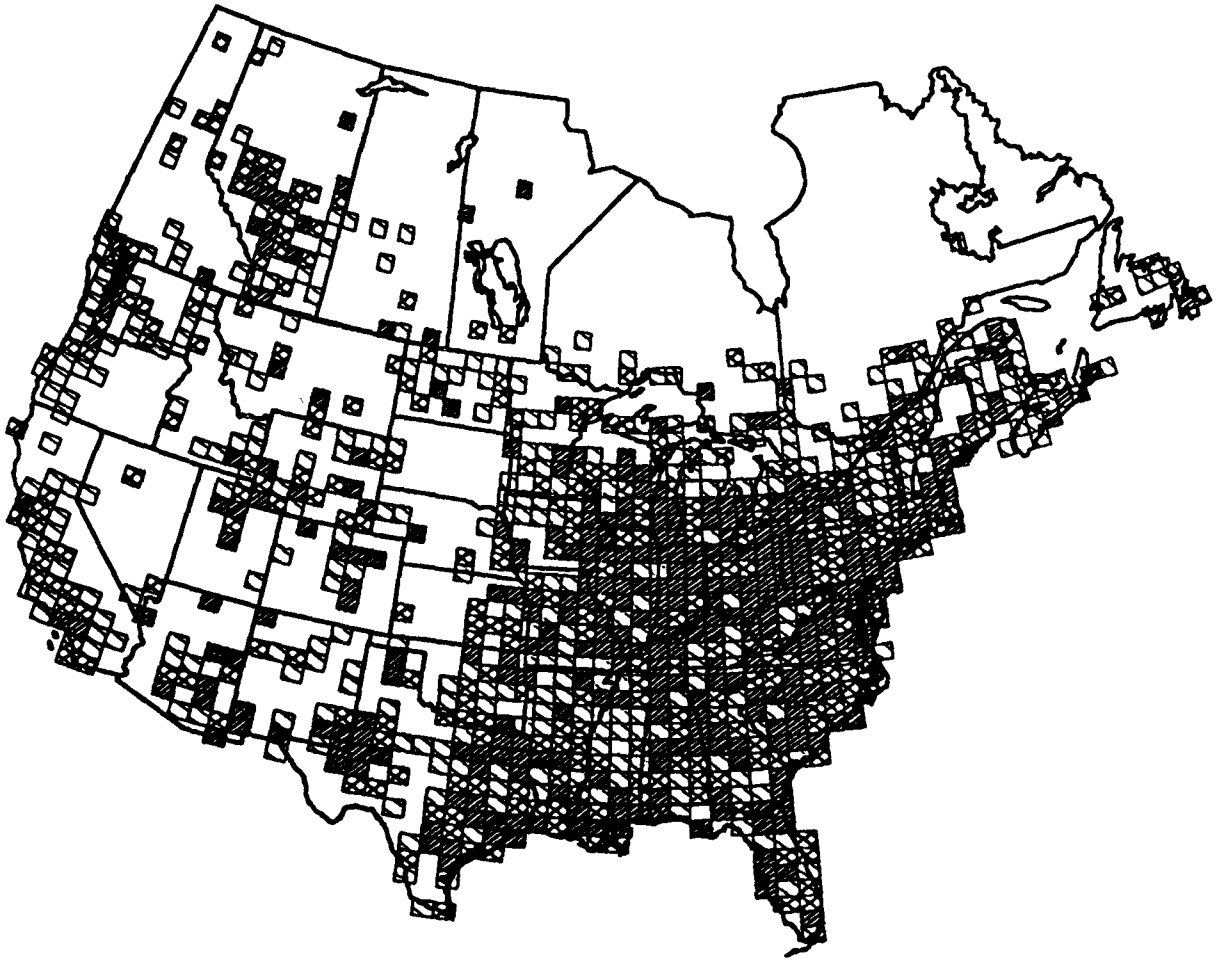
Quality Assurance and Quality Control

Quality assurance and quality control activities (QA/QC) were major efforts for both the annual and modelers' inventories. The annual inventory was developed through a cooperative effort involving EPA, Environment Canada, and state and provincial governments. Early in the inventory planning, a decision was made to involve the states and provinces to the maximum extent possible. The 1985 NAPAP inventory was the first air emissions inventory to be developed with significant and repeated input from local agencies. Thus, the 1985 NAPAP Emissions Inventory (Version 2) is considered the most complete and accurate international inventory of air pollutants ever assembled.

Specific QA/QC procedures applied to the annual inventory included completeness checks, range checks, a separate analysis of utility emissions data, an emissions confirmation by the facilities for the largest emitters, and identification of missing values for a list of priority data items. A separate inventory of utility source emissions and operating data known as the National Utility Reference File (NURF) was used as an independent check of utility emissions for the U.S.

The annual inventory was processed through the Flexible Regional Emissions Data System (FREDS), the series of computer programs that apply spatial, temporal, and species allocation factors to the annual data. During the inventory development effort, a comprehensive QA/QC program was performed on the FREDS code and the FREDS supporting files. The emissions data were summed after each step of FREDS processing to ensure that emissions were neither gained nor lost during the allocation process.

A complete list of the products of this program in written and magnetic forms is included with the report ordering information at the end of this Summary.



Grid Size is 2/3° Latitude by 1° Longitude

Figure 2. *1985 NAPAP Emissions Inventory (Version 2)—U.S. and Canadian annual SO_2 emissions.*

Mark Saeger is with Alliance Technologies Corporation, Chapel Hill, NC 27514.
***Charles Masser** is the EPA Project Officer (see the following page).*
The complete report consists of paper copy, magnetic tapes and diskettes entitled "The 1985 NAPAP Emissions Inventory (Version 2): Development of the Annual Data and Modelers' Tapes:"
Paper Copy (Order No. PB 91-119 669; Cost: $66.00, subject to change)
Cost of diskettes and magnetic tapes includes paper copy (see below):

U.S. Modeler's Point Source Data: (Order No. PB91-505 586; Cost: $360.00)
Canadian Modeler's Point Source Data: (Order No. PB91-505 594; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modeler's Tape - Winter Weekday: (Order No. PB91-505 602; Cost: $240.00)
U.S. and Canada THC Nonmobile Sources Modeler's Tape Winter Weekday: (Order No. PB91-505 610; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modeler's Tape - Winter Weekday: (Order No. PB91-505 628; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modeler's Tape - Winter Weekday: (Order No. PB91-505 636; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modelers' Tape: - Winter Saturday (Order No. PB91-505 644; Cost: $360.00)
U.S. and Canada THC Nonmobile Sources Modelers' Tape - Winter Saturday (Order No. PB91-505 651; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modeler's Tape - Winter Saturday (Order No. 91-505 669; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modeler's Tape - Winter Saturday (Order No. PB91-505 677; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modelers' Tape - Winter Sunday (Order No. PB91-505 685; Cost: $360.00)
U.S. and Canada THC Nonmobile Sources Modelers' Tape - Winter Sunday (Order No. PB91-505 693; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modelers' Tape - Winter Sunday (Order No. PB91-505 701; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modelers' Tape - Winter Sunday (Order No. PB91-505 719; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modelers' Tape - Fall Weekday (Order No. PB91-505 727; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modeler's Tape - Fall Saturday (Order No. PB91-505 735; Cost: $360.00)
U.S. and Canada THC Nonmobile Sources Modelers' Tape - Fall Saturday (Order No. PB91-505 743; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modelers' Tape - Fall Saturday; (Order No. PB91-505 750; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modelers' Tape - Fall Saturday (Order No. PB91-505 768; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modeler's Tape - Fall Sunday (Order No. PB91-505 776; Cost: $360.00)
U.S. and Canada THC Nonmobile Sources Modeler's Tape - Fall Sunday (Order No. PB91-505 784; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modelers' Tape - Fall Sunday (Order No. PB91-505 792; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modeler's Tape - Fall Sunday (Order No. PB91-505 800; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Winter Weekday (Order No. PB91-505 818; Cost $240.00)
U.S. and Canada Natural Particulate Sources Modeler's Tape - Winter Saturday (Order No. PB91-505 826; Cost : $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Winter Sunday (Order No. PB91-505 834; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Spring Weekday (Order No. PB91-505 842; Cost: $240.00
U.S. Annual Point Sources (Order No. PB91-505 859; Cost: $240.00)
Canadian Annual Point Sources (Order No. PB91-505 807; Cost: $240.00)
U.S. Annual Area Sources (Order No. PB91-505 875; Cost: $240.00)
Canadian Annual Area Sources (Order No. PB91-505 883; Cost: $240.00)
U.S. Annual Natural Particulate Sources (Order No. PB91-505 891; Cost: $240.00)
Canadian Annual Natural Particulate Sources (Order No. PB91-505 909; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modelers' Tape - Spring Weekday (Order No. PB91-505 917; Cost: $360.00)
U.S. and Canada THC Nonmobile Sources Modelers' Tape - Spring Weekday (Order No. PB91-505 925; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modelers' Tape - Spring Weekday (Order No. PB 91-505 933; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modelers' Tape - Spring Weekday (Order No. PB 91-505 941; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modelers' Tape - Spring Saturday (Order No. PB91-505 958; Cost: $360.00)
U.S. and Canada THC Nonmobile Sources Modelers' Tape -Spring Saturday; (Order No. PB91-505 966; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modelers' Tape - Spring Saturday (Order No. PB91-505 974; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modelers' Tape - Spring Saturday (Order No. PB91-505 982; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modelers' Tape - Spring Sunday (Order No. PB91-505 990; Cost : $360.00)
U.S. and Canada THC Nonmobile Sources Modelers' Tape - Spring Sunday (Order No. PB91-506 006); Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modelers' Tape - Spring Sunday (Order No. PB91-506 014; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modelers' Tape - Spring Sunday (Order No. PB91-506 022; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modelers' Tape - Summer Weekday (Order No. PB91-506 030; Cost: $360.00)
U.S. and Canada THC Nonmobile Sources Modelers' Tape - Summer Weekday (Order No. PB91-506 048; Cost: $360.00)

☆U.S. GOVERNMENT PRINTING OFFICE: 1992 - 648-080/40157

U.S. and Canada TSP Mobile Sources Modelers' Tape - Summer Weekday (Order No. PB91-506 055; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modelers' Tape - Summer Weekday (Order No. PB91-506 063; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modelers' Tape - Summer Saturday (Order No. PB91-506 071; Cost: $360.00)
U.S. and Canada THC Nonmobile Sources Modelers' Tape - Summer Saturday (Order No. PB91-506 089; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modelers' Tape - Summer Saturday (Order No. PB91-506 097; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modelers' Tape - Summer Saturday (Order No. PB91-506 105; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modelers' Tape - Summer Sunday (Order No. PB91-506 113; Cost: $360.00)
U.S. and Canada THC Nonmobile Sources Modelers' Tape - Summer Sunday (Order No. PB91-506 121; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modelers' Tape - Summer Sunday (Order No. PB91-506 139; Cost: $240.00)
U.S. and Canada TSP Nonmobile Sources Modelers' Tape - Summer Sunday (Order No. PB91-506 147; Cost: $240.00)
U.S. and Canada THC Mobile Sources Modelers' Tape - Fall Weekday (Order No. PB91-506 154; Cost : $360.00)
U.S. and Canada THC Nonmobile Sources Modeler's Tape - Fall Weekday (Order No. PB91-506 162; Cost: $360.00)
U.S. and Canada TSP Mobile Sources Modelers' Tape - Fall Weekday (Order No. PB91-506 170; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Spring Saturday (Order No. PB91-506 188; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Spring Sunday (Order No. PB91-506 196; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Summer Weekday (Order No. PB91-506 204; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Summer Saturday (Order No. PB91-506 212; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Summer Sunday (Order No. PB91-506 220; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Fall Weekday (Order No. PB91-506 238; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Fall Saturday (Order No. PB91-506 246; Cost: $240.00)
U.S. and Canada Natural Particulate Sources Modelers' Tape - Fall Sunday (Order No. PB91-506 253; Cost: $240.00)
Appendix A -- 7 diskettes (Order No. PB92-501 139; Cost: $195.00)

The above items and those on the previous page will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati, OH 45268

Official Business
Penalty for Private Use $300

EPA/600/S7-89/012