



Project Summary

Development of the 1980 NAPAP Emissions Inventory

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This report documents the development of the 1980 National Acid Precipitation Assessment Program (NAPAP) Emissions Inventory. The current version of the annual inventory, Version 5.0, and the related Version 5.2 Eulerian Modeling Inventory and Version 5.3 Regional Oxidant Modeling Inventory represent the most comprehensive, highest quality emissions data available for the 1980 base year. The inventory spans the 48 contiguous states and 10 Canadian provinces, providing detailed point source data for over 14,000 plants and area source information by source category for 3,070 U.S. counties. Canadian area source data are reported at the province level. Emissions from 11 pollutants (SO_2 , SO_4 , NO_x , Pb, CO, HCl, HF, NH_3 , TSP, VOC, and total hydrocarbons) are included in Version 5.0 of the inventory, while in the 5.2 modeling inventory, pollutants are disaggregated into 39 individual classes. NAPAP Version 5.0/5.2 emissions of SO_2 , NO_x , and VOC are 32.1, 24.4, and 26.2 million tons/year, respectively. Summaries of emissions data are presented at various levels of aggregation including nation, EPA region, state/province, and source category. 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 Version 5.0 NAPAP Emissions Inventory represents the last of a series of NAPAP inventory compilation efforts for base year 1980. This report provides a history of the inventory development, focusing on enhancements made from version to version. It also includes a number of topics specific to development of Versions 5.0

and 5.2, including development of emission factors for newly added pollutants; incorporation of updated utility data with information from the NAPAP Utility Reference File (NURF); development of temporal, spatial, and species allocation factors; and creation of the Flexible Regional Emissions Data System, used to process the 5.0 inventory into the 5.2 and 5.3 modeling inventories.

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 1980 NAPAP Emissions Inventory has been developed by the Task Group on Emissions and Controls of the National Acid Precipitation Assessment Program (NAPAP). This report summarizes the data in the emissions inventory, and documents the history of its development and enhancements to previous versions.

The Inventory represents the best available point and area source emissions data for the U.S. and Canada for the base year 1980. The NAPAP study area extends from 25 to 60 degrees north latitude and from 50 to 125 degrees west longitude.

Annual Emissions Inventory

Within the NAPAP study area, the inventory contains annual point source emissions data for 14,244 plants encompassing 36,807 emission points and

52,904 source classification code (SCC) or process level records. Area source emissions are reported for 88 emissions categories for the 3,070 counties in the 48 contiguous United States and Washington, DC, and for 157 categories for 10 Canadian provinces. Emissions for 11 pollutants are reported in the annual emissions inventory: SO₂, SO₄, NO_x, Pb, CO, HCl, HF, NH₃, TSP, VOC, and THC. Volatile organic compounds (VOCs) are defined as reactive hydrocarbon species; whereas, total hydrocarbons (THCs) include both reactive and nonreactive species. This annual emissions inventory is termed "Version 5.0."

Eulerian Modeling Emissions Inventory

NAPAP requires an emissions inventory that is suitable as input to the Regional Acid Deposition Model (RADM), which dictates that annual emissions be further resolved temporally, spatially, and by pollutant species.

Temporal resolution is accomplished by applying factors which allocate annual emissions to 24 hourly emissions totals for a "typical" weekday, Saturday, and Sunday in each season, giving a total of 12 temporal scenarios, each suitable as RADM input. The point source and county-level area source emissions are spatially allocated to 63,000 20 × 20 km grid cells, each representing 1/6-degree latitude by 1/4-degree longitude.

Three pollutants from the annual inventory (NO_x, TSP, and total hydrocarbons) are further resolved into constituent species or classes of species. Although the data handling system was designed to accommodate the 29 hydrocarbon classes used in the RADM, lack of speciation profiles resulted in estimated emissions of zero for some classes. In addition, NO_x emissions were not maintained in the resolved inventory following speciation into NO and NO₂. As a result, the Eulerian Modeling Emissions Inventory (Version 5.2) contains 39 pollutants:

SO ₂	Sodium	Other Alkanes
SO ₄	VOC	Other Alkenes
NO	THC	Other Organic Acids
NO ₂	Methane	Formaldehyde
Pb	Ethane	Acetaldehyde
CO	Ethylene	Acetone
HCl	Propane	Other Ketones
HF	Propylene	Other Aldehydes
NH ₃	N-butane	Xylene
TSP	Isobutane	Benzene
Calcium	Isobutene	Toluene
Magnesium	Pentane	Ethylbenzene
Potassium	Isopentane	Other Aromatics

Emissions Summary

Annual Emissions Inventory

Table 1 details the annual U.S. and Canadian emissions of the 11 pollutants in Version 5.0 of the 1980 NAPAP Emissions Inventory. The distribution of SO₂ emissions among major source categories and by source type (point and area) is shown in Figure 1. Clearly, point sources (mainly utilities and smelters) are the major SO₂ emitters. State and county SO₂ emission density maps are shown in Figures 2 and 3; the concentration of SO₂ emissions east of the Mississippi River is apparent. This report contains similar maps for additional pollutants; SO₂ is used here as an example.

Eulerian Modeling Emissions Inventory

The annual emissions of the 39 species represented in Version 5.2 of the 1980 NAPAP Emissions Inventory are summarized in Table 2. These totals reflect the application of species allocation factors to NO_x, TSP, and THC emissions.

The temporal variability of SO₂ emissions is graphically shown in Figure 4. Since hour 12 Greenwich Mean Time corresponds to 8 a.m. Eastern Daylight Time, it is clear that national SO₂ emissions are greatest during the daytime.

Figure 5 depicts the spatial distribution of SO₂ emissions for a "typical"

summer weekday; again emissions are concentrated in the industrial midwestern states and in the eastern U.S. The figure is plotted on an 80 × 80 km grid system; whereas, the actual inventory contains emissions data at the 1/6-degree latitude by 1/4-degree longitude (approximately 20 × 20 km) level of spatial resolution. This report contains similar maps for additional pollutants; SO₂ is used here as an example.

Inventory Enhancements

Several related NAPAP work assignments resulted in work products which have been applied in the development of the current version of the 1980 NAPAP Emissions Inventory. Emission factors were developed for HCl, HF, NH₃, and SO₄, and applied to generate emissions estimates in the current inventory. A significant improvement to the previous inventory was the integration of the NAPAP Utility Reference File into the inventory, replacing previous National Emissions Data System (NEDS) data with quality assured emissions estimates for the utility sector.

In order to create the Eulerian modeling emissions inventory (Version 5.2) used in the testing of the RADM, temporal, spatial, and species allocation factors were developed. The basis for these factors was the Northeast Corridor Regional Modeling Project (NECRMP); these factors were quality assured and revised as necessary. Allocation factors were developed for those states not considered in the NECRMF study.

These allocation factors and the 1980 NAPAP Annual Emissions Inventory (Version 5.0) were used as inputs to the Flexible Regional Emissions Data System (FREDS), an emissions inventory data processing system developed for NAPAP. Written in the command language of the Statistical Analysis System (SAS), FREDS was designed to allow the vast amount of data in the NAPAP inventory to be processed efficiently.

EPA's Atmospheric Sciences Research Laboratory requested that a

Table 1. 1980 NAPAP Emissions Inventory Version 5.0 - Area and Point Sources^a

Country	SO ₂	SO ₄	NO _x	Pb	CO	HCl	HF	NH ₃ ^b	TSP ^b	VOC ^b	THC
Canada	5,109	188	2,054	^c	18,036	^c	^c	210	31,574	2,994	5,174
Contiguous U.S.	26,954	976	222,352	32	99,309	527	115	839	42,617	23,165	24,974
Total	32,063	1,164	24,406	32	117,345	527	115	1,048	74,192	26,158	30,114

^aIn 1000s of tons/yr

^bNumbers do not add due to rounding

^cNot reported

emissions inventory be developed to enable testing of the Regional Oxidant Model (ROM) which requires hydrocarbon species consistent with Carbon Bond IV mechanisms as input. The flexibility of FREDS was utilized and a Version 5.3 inventory was developed.

An uncertainty methodology was developed by Brookhaven National Laboratory and applied to the 1980 NAPAP Emissions Inventory; this effort and its results will be documented in a separate EPA report.

A complete list of the products of this effort in printed and magnetic form is attached as Table 3.

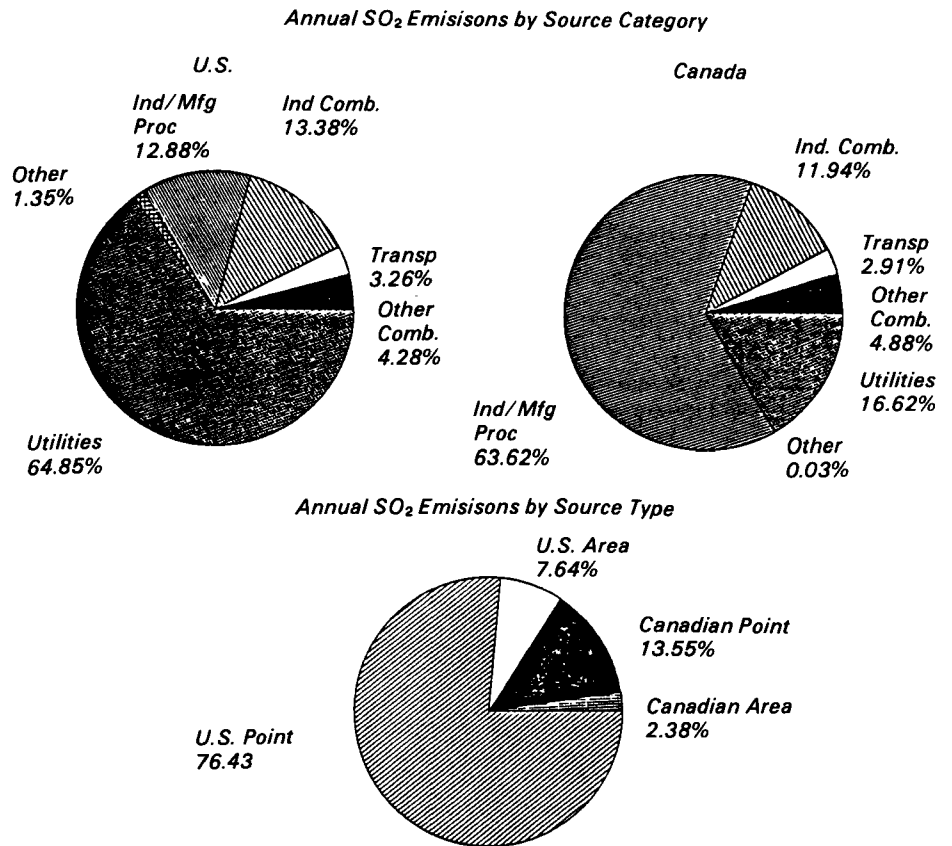


Figure 1. 1980 NAPAP Emissions Inventory Version 5.0—SO₂ emissions by source category and source type.

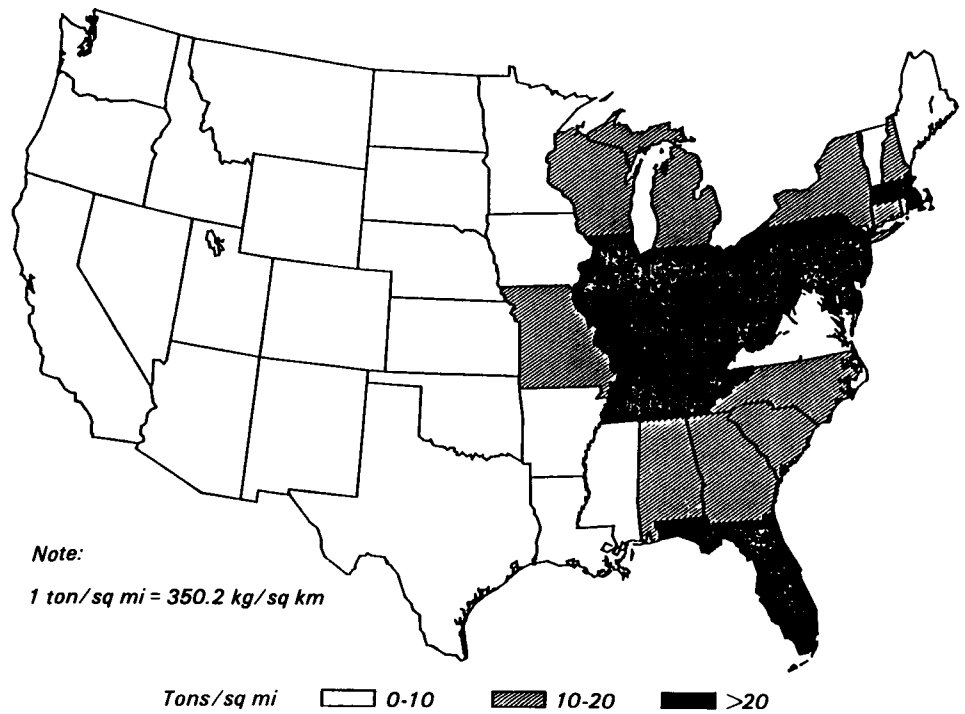


Figure 2. 1980 NAPAP Emissions Inventory Version 5.0—SO₂ state emissions density.

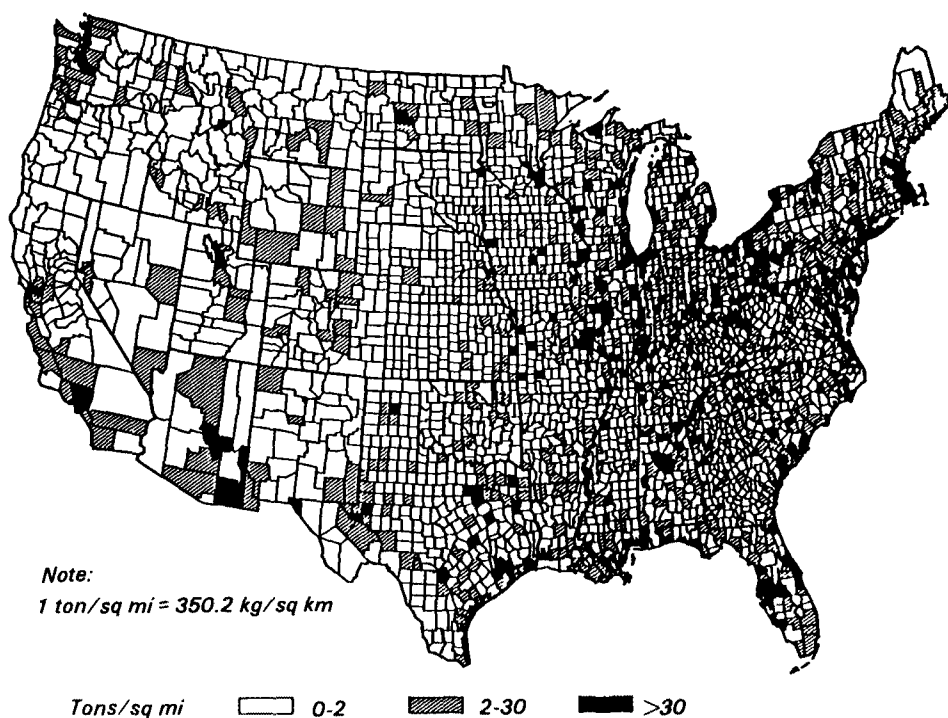


Figure 3. 1980 NAPAP Emissions Inventory Version 5.0—SO₂ county emissions density.

Table 2. 1980 NAPAP Emissions Inventory Version 5.2 - Area and Point Sources

1980 NAPAP 5.2 Emissions Inventory - Annual Canadian & U.S. Emissions, Area & Point Sources^a

Country	SO ₂	SO ₄	NO	NO ₂	PB	CO	HCl	HF	NH ₃	TSP	Ca	Mg	Na	K	VOC	THC
Canada	5,095	167	1,879	171	^b	17,986	^b	^b	210	31,509	17	5	3	3	2,992	5,135
Contig. U.S.	26,954	976	20,877	1,475	32	99,309	527	115	839	42,617	114	32	13	15	23,165	24,977
Total	32,049	1,143	22,756	1,646	32	117,295	527	115	1,049	74,126	130	37	16	18	26,156	30,113

1980 NAPAP 5.2 Emissions Inventory - Annual Canadian & U.S. Emissions of Hydrocarbon Species, Area & Point Sources^c

Country	Methane	Ethane	Propane	Butane	Iso-butane	Pentane	Iso-pent	Alkanes
Canada	120,389,361	759,253	1,096,057	2,339,149	643,943	814,803	27,796	15,103,733
Contig. U.S.	91,994,146	6,698,261	4,079,718	15,972,045	3,301,153	3,294,293	340,374	134,447,565
Total	212,383,507	7,457,514	5,175,775	18,311,194	3,945,097	4,109,096	368,171	149,551,298

Country	Ethylene	Propylene	Iso-butene	Alkenes	Benzene	Toluene	Xylene	Eth Benz
Canada	9,434,992	2,001,986	14,897	6,317,955	547,649	1,172,180	1,129,434	238,103
Contig. U.S.	41,611,730	15,457,664	103,241	28,722,513	5,492,770	16,492,428	13,762,475	2,870,820
Total	51,046,722	17,459,650	118,138	35,040,468	6,040,419	17,664,608	14,891,909	3,108,923

Country	Aromatic	Formaldehy	Acetaldehy	Aldehyde	Acetone	Ketones	Org. Acid
Canada	398,445	2,626,378	330,143	105,814	424,770	309,714	33,100
Contig. U.S.	4,011,537	19,199,592	2,247,947	816,293	7,253,977	4,376,829	1,594,637
Total	4,409,982	21,825,970	2,578,090	922,107	7,678,747	4,686,543	1,627,737

^aIn 1000s of tons/yr
^bNot reported
^cIn 1000s of moles/yr

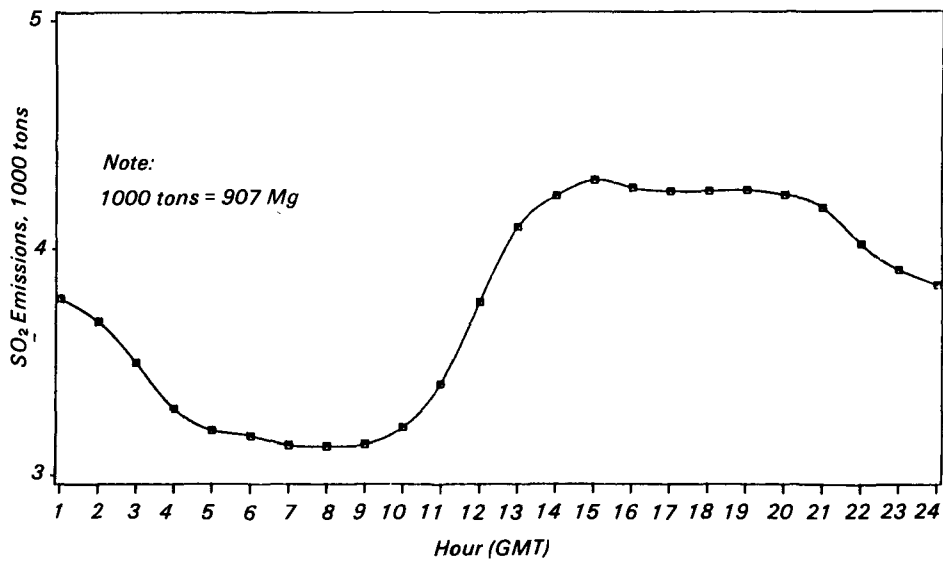


Figure 4. 1980 NAPAP Emissions Inventory Version 5.2—hourly emissions pattern for SO₂ for a typical summer weekday.

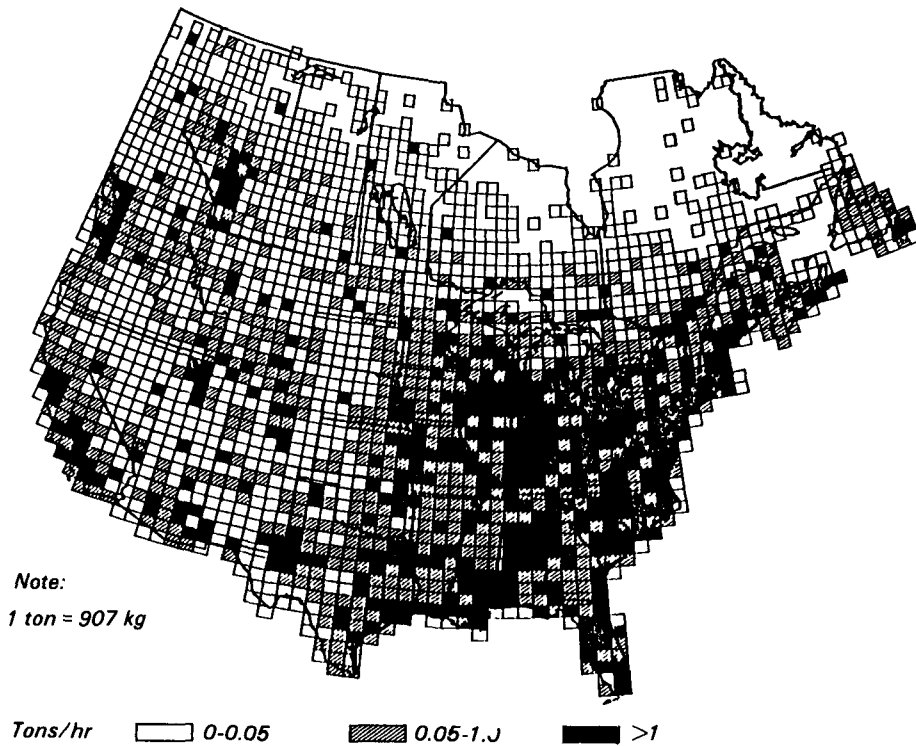


Figure 5. 1980 NAPAP Emissions Inventory Version 5.2—SO₂ emissions for a typical summer weekday at 1700 GMT.

Table 3. NAPAP Version 5 Products^a

<i>Product</i>	<i>Version</i>	<i>Description</i>	<i>Temporal resolution</i>
A	5.0/5.2/5.3	Development of the 1980 NAPAP Emissions Inventory (Report)	
B	5.0	U.S. Point Sources	Annual
C		Canada Point Sources	
D		U.S. Area Sources	
E		Canada Area Sources	
F	5.2	Point Sources	Hourly
G		Area Sources - Winter Weekday ^b	
H		Area Sources - Winter Saturday	
I		Area Sources - Winter Sunday	
J		Area Sources - Spring Weekday	
K		Area Sources - Spring Saturday	
L		Area Sources - Spring Sunday	
M		Area Sources - Summer Weekday	
N		Area Sources - Summer Saturday	
O		Area Sources - Summer Sunday	
P		Area Sources - Fall Weekday	
Q		Area Sources - Fall Saturday	
R		Area Sources - Fall Sunday	
S	5.3	Point Sources	Hourly
T		Area Sources - Winter Weekday	
U		Area Sources - Winter Saturday	
V		Area Sources - Winter Sunday	
W		Area Sources - Spring Weekday	
X		Area Sources - Spring Saturday	
Y		Area Sources - Spring Sunday	
Z		Area Sources - Summer Weekday	
AA		Area Sources - Summer Saturday	
BB		Area Sources - Summer Sunday	
CC		Area Sources - Fall Weekday	
DD	Area Sources - Fall Saturday		
EE	Area Sources - Fall Sunday		

^aData on all tapes are in EBCDIC characters

^bArea sources are divided into two regions, separated at 100°W longitude

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J. David Mobley is the EPA Project Officer (see below).

The complete report, entitled "Development of the 1980 NAPAP Emissions Inventory," (Order No. PB 88-132 121/AS; Cost: \$38.95, subject to change)

Tapes associated with this project are as follows: (cost of tape includes paper copy of report)

"U.S. Point Sources (Version 5.0)—Product B," (Order No. PB 88-137 138/AS; Cost: \$300.00)

"Canadian Point Sources (Version 5.0)—Product C," (Order No. PB 88-137 146/AS; Cost: \$200.00)

"U.S. Area Sources (Version 5.0)—Product D," (Order No. PB 88-137 153/AS; Cost: \$1,000.00)

"Canadian Area Sources (Version 5.0)—Product E," (Order No. PB 88-137 161/AS; Cost: \$200.00)

"Point Sources (Version 5.2)—Product F," (Order No. PB 88-137 179/AS; Cost: \$400.00)

"U.S. Area Sources—Winter Weekday (Version 5.2)—Product G," (Order No. PB 88-137 187/AS; Cost: \$700.00)

"Area Sources—Winter Saturday (Version 5.2)—Product H," (Order No. PB 88-137 195/AS; Cost: \$700.00)

"Area Sources—Winter Sunday (Version 5.2)—Product I," (Order No. PB 88-137 203/AS; Cost: \$700.00)

"Area Sources—Spring Weekday (Version 5.2)—Product J," (Order No. PB 88-137 211/AS; Cost: \$700.00)

"Area Sources—Spring Saturday (Version 5.2)—Product K," (Order No. PB 88-137 229/AS; Cost: \$700.00)

"Area Sources—Spring Sunday (Version 5.2)—Product L," (Order No. PB 88-137 237/AS; Cost: \$700.00)

"Area Sources—Summer Weekday (Version 5.2)—Product M," (Order No. PB 88-137 245/AS; Cost: \$700.00)

"Area Sources—Summer Saturday (Version 5.2)—Product N," (Order No. PB 88-137 252/AS; Cost: \$700.00)

"Area Sources—Summer Sunday (Version 5.2)—Product O," (Order No. PB 88-137 260/AS; Cost: \$700.00)

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"Area Sources—Fall Saturday (Version 5.2)—Product Q," (Order No. PB 88-137 286/AS; Cost: \$700.00)

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"Point Sources (Version 5.3)—Product S," (Order No. PB 88-137 302/AS; Cost: \$300.00)

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"Area Sources—Summer Sunday (Version 5.3)—Product BB," (Order No. PB 88-137 393/AS; Cost: \$500.00)

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"Area Sources—Fall Weekday (Version 5.3)—Product CC," (Order No. PB 88-137 401/AS; Cost: \$500.00)

"Area Sources—Fall Saturday (Version 5.3)—Product DD," (Order No. PB 88-137 419/AS; Cost: \$500.00)

"Area Sources—Fall Sunday (Version 5.3)—Product EE," (Order No. PB 88-137 427/AS; Cost: \$500.00)

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National Technical Information Service

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