United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/4-91-014
May 1991

Air

EPA

PROCEDURES FOR THE PREPARATION OF EMISSION INVENTORIES FOR CARBON MONOXIDE AND PRECURSORS OF OZONE

VOLUME II: EMISSION INVENTORY REQUIREMENTS FOR PHOTOCHEMICAL AIR QUALITY SIMULATION MODELS

EPA-450/4-91-014

PROCEDURES FOR THE PREPARATION OF EMISSION INVENTORIES FOR CARBON MONOXIDE AND PRECURSORS OF OZONE

VOLUME II: EMISSION INVENTORY REQUIREMENTS FOR PHOTOCHEMICAL AIR QUALITY SIMULATION MODELS

By

LuAnn Gardner
Lyle R. Chinkin
Jeremy G. Heiken

Systems Applications International
San Rafael, CA

EPA Contract No. 68-DO-0124

EPA Project Officer: Keith Baugues

Office Of Air Quality Planning And Standards
Office Of Air And Radiation
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

May 1991

This report has been reviewed by the Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, and has been approved for publication as received from the contractor. Approval does not signify that the contents necessarily reflect the views and policies of the Agency, neither does mention of trade names or commercial products constitute endorsement or recommendation for use.

EPA-450/4-91-014

ACKNOWLEDGEMENTS

The authors would like to express appreciation to the various persons involved in the planning and review of this document; of particular note are the contributions of Keith Baugues and David Misenheimer of the Office of Air Quality Planning and Standards, EPA, and Marianne Causley, Jay Haney, and Ralph Morris of Systems Applications International. Additionally, the authors wish to acknowledge the work of Tom Lahre (EPA OAQPS), Dr. Lowell Wayne (Pacific Environmental Services), and Keith Rosbury (PEDCo Environmental) in preparing the original version of this document (EPA-450/4-79-018), published in 1979.

PREFACE

This document is the second volume of a two volume series designed to provide assistance to air pollution control agencies in preparing and maintaining emission inventories for carbon monoxide (CO) and precursors of ozone (O_3). Emission inventories provide the foundation for most air quality control programs. The first volume of this series describes procedures for preparing inventories of volatile organic compounds (VOC), oxides of nitrogen (NO_x) and CO on a countywide annual or seasonal basis. The 1990 Clean Air Act Amendments require such an inventory for establishing a baseline in O_3 nonattainment areas and also require an inventory of CO emissions for CO nonattainment areas.

This second volume offers technical assistance to those engaged in the planning and development of detailed inventories of VOC, NO_x, and CO for use in photochemical air quality simulation models. Such inventories must be resolved both spatially and temporally and must also be speciated into several classes of VOC, NO, and NO_2. These inventories are required of the more serious O_3 and CO nonattainment areas only.

This volume has been revised from the 1979 version to include current information pertinent to gridding, speciation, and temporal allocation of emission inventories of CO and precursors of O_3. This edition includes changes and additions as summarized below:

- Inclusion of an additional section containing a brief overview of the Urban Airshed Model (UAM) and the UAM Emissions Preprocessor System.

- Inclusion of an additional section regarding techniques for estimating emissions from biogenic sources.

- Revision of the section regarding highway motor vehicles to provide guidance for developing spatially and temporally resolved exhaust, evaporative, refueling, and running loss emission estimates from annual and seasonal county-level total emissions by vehicle type.

- Discussion of currently available computerized data bases useful for the inventory development process.

- Inclusion of specific guidance for employment of the UAM Emissions Preprocessor System.

- Discussion of considerations specific to modeling for CO non-attainment applications.

EXECUTIVE SUMMARY

This document offers technical assistance to those engaged in planning and development of detailed emission inventories for use in photochemical air quality simulation models. It is intended to supplement Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I, which outlines procedures for compiling basic annual and seasonal emission inventories at a spatial resolution of county, township, or equivalent level. Volume II provides guidance for identifying and incorporating the additional detail required by photochemical air quality simulation models into an existing inventory of the type described above, with a special emphasis on fulfilling the input requirements of the Urban Airshed Model.

In order for photochemical simulation models to accurately predict temporal and spatial variations in modeled ozone and CO concentrations, the emission inventories input to these models must contain considerably more detail than an inventory generated using the procedures prescribed in Volume I. The primary additional requirements of the photochemical modeling inventory are summarized below.

- Emission estimates of precursor pollutants must be provided for each individual cell of a grid system within the area instead of at a county or regional level;
- Typical hour-by-hour emission estimates must be provided instead of annual or seasonally adjusted emissions;
- Total reactive VOC and NO_x emissions estimates must be disaggregated into several classes of VOC and NO and NO_2, respectively; spatially and temporally resolved emission estimates of CO may also be required (EPA requires that CO emissions be input to the UAM in ozone attainment demonstrations)
- If the model provides for vertical resolution of pollutants, stack and exhaust gas parameters must be provided for each large point source.

This document presents detailed methodologies for developing the additional resolution required for photochemical modeling.

Volume II addresses four basic operations used in development of the photochemical modeling inventory: (1) planning the inventory development effort, (2) collecting any necessary data, (3) analyzing this data and using it to develop the additional resolution required of the modeling inventory, and (4) reporting this data in a format which facilitates its use (data handling). Each of these operations is summarized below.

Inventory Planning and Design. The requirements of photochemical modeling inventories necessitate additional planning considerations. This document provides a discussion of the following design issues:

- Selecting an appropriate modeling region and grid system;
- Evaluating existing emission inventories to assess their suitability as a basis for the photochemical modeling inventory;
- Planning the data collection effort, which includes identifying the data requirements of the photochemical model and prioritizing specific data needs;
- Special planning considerations related to the development of inventory projections;
- Special considerations for developing CO nonattainment inventories;
- Coordinating the inventory development effort with other agencies; and
- Developing appropriate data handling systems for the emissions-related data;

Note that this document is not intended to replace existing EPA guidance on topics other than the development of photochemical modeling inventories. Although discussions of other issues have been included for informational purposes, the reader is directed to other guidance documents where appropriate.

Data Collection. Usually, point source, highway motor vehicle, and other area source emissions-related data are acquired separately. It is assumed that a conventional annual or seasonal county-level emission inventory, generated in accordance with the methodologies described in Volume I, already exists, and that additional data must be collected to provide the degree of detail required of the photochemical modeling inventory. Specifically, data must be collected which allows the emissions modeler to assign emissions to grid cells, to determine temporal variations in emissions, and to estimate the proportions of VOC and NO_x to be assigned to the chemical species or classes required in the model.

Preparation of the Modeling Inventory. As mentioned above, the photochemical modeling emission inventory must contain detailed spatial, temporal, and chemical information. In this document, separate chapters provide detailed methodologies for incorporating this additional degree of resolution for point sources, mobile sources, and area sources; specific data handling considerations are also addressed for each of these source types.

Additionally, specific guidance and examples regarding the application of the Urban Airshed Model Emissions Preprocessor System to facilitate modeling inventory development is provided throughout the document. Specific topics covered are described below.

For point sources, data collection techniques and spatial and temporal resolution methodologies are discussed in detail. Additional information is provided regarding projection of point source emissions for both individual facilities and at the aggregate level, including a discussion of control strategy projections. Specific data handling considerations are also addressed.

For area sources, general methodologies for spatial resolution are presented, including determination of emissions at the grid cell level and the use of spatial allocation surrogates. Detailed examples of the development of spatial allocation surrogates from land use data and demographic parameters are provided. Additional sections regarding temporal resolution methodologies, projection techniques, and data handling considerations are also included.

For mobile sources, selection of appropriate emission source categories is addressed. Procedures for adjusting existing annual or seasonal emission estimates to be representative of modeling episode conditions are discussed, and methodologies for spatial resolution of mobile source emissions using both link- and nonlink-based surrogates are presented. Temporal resolution methodologies are also addressed.

In addition to the topics listed above, a separate chapter discusses estimation procedures for biogenic emissions, focusing on EPA's Biogenic Emission Inventory System (BEIS). An overview of the BEIS is provided along with a discussion of BEIS input requirements and the use of user-specified land use data in the BEIS. Special considerations for projection year inventories of biogenic emissions are also discussed.

Finally, a separate chapter is provided which discusses speciation of VOC and NO_x emissions into chemical classes as required by the photochemical model. This chapter includes an overview of the Carbon Bond IV Mechanism employed by the Urban Airshed Model as well as specific methodologies for the identification of appropriate split factors for both base year and projected inventories. Compatibility of split factors with the emission inventory data and classification scheme are addressed, and special data handling considerations are outlined.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Figures

Tables

1 INTRODUCTION

1.1 PURPOSE

This document supplements Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I. Volume I outlines procedures for compiling annual and seasonal emission inventories, which provide the basis for development of the emission inventories required for use with photochemical grid models such as the Urban Airshed Model. Generally, the basic inventory will contain annual or seasonal estimates of reactive or total VOC, NO_x, and CO, at a spatial resolution of county, township, or equivalent level.

Volume II describes procedures for identifying and incorporating the additional detail required by photochemical air quality simulation models into an existing inventory of the type described above. Because photochemical models can simulate the hour-by-hour photochemistry occurring over numerous, small subcounty areas, such as grid cells, the input emissions data must be more highly resolved (i.e., chemically speciated and spatially distributed by grid cell) than required by source/receptor models. Total VOC and NO_x emissions must be apportioned into chemical classes, and information may be required on other pollutants such as carbon monoxide. Furthermore, evaluation of proposed control strategies using photochemical air quality simulation models requires that projected "future year" inventories which incorporate anticipated changes in emissions levels and temporal and spatial distribution patterns be constructed at the same level of detail as required for the base year inventories. This document presents methodologies for providing this additional detail. In each case, the requirements for projected inventories are equivalent to those for current or "base year" inventories.

The basic emission inventory requirements for photochemical models and the less data-intensive source/receptor relationships are in many respects quite similar. For both, much of the same information must be obtained from the same sources. Additionally, the resulting inventories are used by air pollution control agencies for the same general purpose: development of control strategies that will assure the achievement and maintenance of the National Ambient Air Quality Standards for ozone and CO. Consequently, for many activities such as data collection and emission calculations, the same considerations and techniques will apply regardless of whether the inventories are being developed for a photochemical model or a source/receptor relationship. In general, procedures which are similar to those already described in detail in Volume I will not be repeated here. Thus, the reader should be familiar with the contents of Volume I in order to thoroughly understand the procedures described in this document.

Since the EPA-recommended photochemical model for urban applications is the Urban Airshed Model (UAM), this document emphasizes methods for preparing emission inventories that fulfill the input requirements of UAM. The data collection methodologies discussed, however, can usually be applied to generate emission inventories that are generally suitable for use in any photochemical grid model.

It is assumed at the outset that an annual or seasonal county-level emission inventory (such as can be generated following the methodologies discussed in Volume I) is available as a starting point for the photochemical modeling effort. This basic inventory is useful both in planning the more detailed emission inventory effort and as a source of certain data. For most urban areas, some sort of basic emission inventory has already been developed.

1.2 BACKGROUND

As described in Volume I, the emission inventory is essential for the development and implementation of an effective ozone or CO control strategy. It tells the air pollution control agency what sources are present in an area, how much of each ozone precursor pollutant or how much CO is emitted by each source, and what types of processes and control devices are employed at each plant. Ultimately, the emission inventory is utilized in conjunction with a source/receptor relationship of some kind for the development of an ozone control strategy.

Two basic approaches may be used to relate photochemical ozone to precursor emissions. The first method involves the use of empirical relationships such as EKMA to relate ambient ozone concentrations with precursor emissions over fairly broad geographical areas. These models provide answers to questions such as "what level of overall volatile organic compound emission control is needed to attain the ozone standard in an urban area?" or "what reduction in maximum ozone concentration will accompany a specified reduction in ambient levels of volatile organic compounds?"

The second basic approach for relating ozone to precursor emissions involves the use of photochemical air quality simulation models. These models, which offer a more theoretically sound approach for control strategy development than the source/receptor models mentioned above, attempt to simulate the photochemical reactions that occur over an urban region during each hour of the day or days for which the model is being applied. Because of their ability to provide detailed spatial and temporal information on concentrations of both ozone and precursor pollutants and because they can directly relate emissions to ozone concentrations, photochemical simulation models offer considerable potential for use in control strategy design and evaluation.

In addition to answering the limited questions that the empirical source/receptor relationships may address, photochemical models enable strategists to make more sophisticated determinations relating to control program development. For example, photochemical models enable control agencies to judge whether it is more effective to control only certain precursor sources within an urban area rather than all sources, or where (and when) benefits from various control options are most likely to occur within an urban area. Another application is the development of environmental impact assessments, since photochemical models allow an agency to evaluate the impact of new precursor sources (e.g., a major highway) at various receptor locations. Photochemical models are also useful in basic scientific research, such as in validation studies of atmospheric photochemistry and dispersion mechanisms.

Grid models (also called Eulerian models) calculate pollutant concentrations at fixed locations in space at specified times. The concentrations estimated at each location result from interaction among emissions, chemical reactions, and transport and dilution introduced by prevailing meteorological conditions. Pollutant concentrations are calculated for each cubicle of a three-dimensional framework in the entire region of interest. A cubicle might have horizontal dimensions of 1 to 10 kilometers on a side and be 50 to 500 meters deep. Some Eulerian models are designed to provide vertical (as well as horizontal) resolution of pollutant concentrations by using a vertical "stack" of cubicles; the Urban Airshed Model, the photochemical model recommended by EPA for ozone control strategy development and evaluation in urban regions, provides this sort of vertical resolution.

In order for photochemical simulation models to accurately predict temporal and spatial variations in modeled ozone and CO concentrations, the emission inventories input to these models must contain considerably more detail than an inventory generated using the procedures prescribed in Volume I. Note, however, that the more detailed inventory will usually be based on and should be consistent with an existing county-level annual or seasonal inventory prepared using the guidance in Volume I. The primary requirements of the gridded photochemical modeling inventory are summarized below.

- Emission estimates of precursor pollutants must be provided for each individual cell of a grid system within the area instead of at a county or regional level;
- Typical hour-by-hour emission estimates must be provided instead of annual or seasonally adjusted emissions;
- Total reactive VOC and NO_x emissions estimates must be disaggregated into several classes of VOC and NO and NO_2, respectively; spatially and temporally resolved emission estimates of CO may also be required (EPA requires that CO emissions be input to the UAM in ozone attainment demonstrations); and

- If the model provides for vertical resolution of pollutants, stack and exhaust gas parameters must be provided for each large point source.

1.3 CONTENTS OF VOLUME II

This document offers technical assistance to those engaged in planning and development of detailed emission inventories for use in photochemical air quality simulation models.

Chapter 1 discusses the purpose of Volume II and its relationship to Volume I; it also includes an introductory description of photochemical air quality simulation grid models and their emission inventory requirements. Chapter 2 describes various technical considerations that aid in the planning and design of the detailed emission inventory process. Chapter 2 is intended to provide an overall perspective of the detailed inventory requirements for those who will actually be utilizing the remainder of the document. Chapter 3 provides a brief overview of the Urban Airshed Model (UAM) and the UAM Emissions Preprocessor System, and Chapter 4 addresses selection of an appropriate modeling region and grid system. Finally, Chapters 5 through 9 provide detailed "how to" procedures for supplying the additional inventory detail required by the photochemical grid model.

For the convenience of the reader, the following typographical conventions will be used throughout this document:

► Text containing specific examples or involved calculations will be indented and denoted by an arrow like the one to the left.

Additionally, information pertaining specifically to the UAM Emissions Preprocessor System will be enclosed in a gray box like this.

2 INVENTORY PLANNING AND DESIGN CONSIDERATIONS

In general, compilation of a detailed emission inventory suitable for photochemical grid modeling (hereafter referred to as a "modeling inventory") involves the same four basic operations required to compile a less detailed inventory suitable for use with models such as EKMA. These steps are (1) planning the inventory development effort, (2) collecting any necessary data, (3) analyzing the data and using it to develop the additional resolution required of the modeling inventory, and (4) reporting the data in a format which facilitates its use (data handling).

Many of the planning and design considerations discussed in Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I (EPA, May 1991) also apply to development of a modeling inventory. (Throughout the remainder of this text, the above document will be referred to as Volume I). The more rigorous requirements of photochemical modeling inventories, however, necessitate additional planning considerations. This chapter identifies these additional requirements and discusses the additional responsibilities imposed on the agency developing the modeling inventory.

2.1 SELECTION OF THE MODELING REGION AND GRID SYSTEM

Before any data collection effort begins, the geographical region to be modeled must be selected based on consideration of available meteorological and air quality data, location of current and expected major emissions sources, and control strategy evaluation objectives. The guidance set forth in the Guideline for Regulatory Application of the Urban Airshed Model (EPA-450/4-91-013, OAQPS, June 1991) should be followed when selecting the modeling region; the following discussion is included for informational purposes only.

The two main elements of the grid system used to identify the modeling region are (1) the grid boundary, which outlines the area to be modeled (the "modeling region"), and (2) the individual grid cells which will be used by the model to subdivide this region. In most cases, the grid boundary will be rectangular and the grid cells will be equally sized squares. Generally, the modeling region should be fairly large for the following reasons:

- to include all major emission sources which may affect ozone formation in the urban area;

- to encompass as many ozone and precursor pollutant monitoring stations as possible (which facilitates model validation);
- to encompass areas of current limited land use activity that are expected to develop significantly as a result of projected growth; and
- to encompass the effects of meteorology in the modeling region.

Note that CO modeling regions do not need to be as large as ozone modeling regions; CO modeling regions usually only contain the nonattainment area.

In some cases, the selection of the modeling region will not be finalized at the time when data collection for the modeling inventory must begin (perhaps due to manpower or scheduling constraints). In this instance, the emission inventory should be developed for as large a region as possible, to ensure that any modeling region finally selected will be encompassed by the region for which emissions data has been collected, preventing any additional data collection effort.

After the grid boundary has been selected, the size and number of grid cells used to subdivide the modeling region must be chosen. Generally, the grid spacing (the length of a square grid cell along one side) should be small to optimize the spatial resolution of emissions. If the grid spacing is too large, the model may lose precision in estimating ozone and precursor pollutant levels. Too small of a grid spacing, however, will result in excessive manpower and computer resource requirements, because data must be collected and compiled for every grid cell in the modeling region.

In most urban ozone modeling applications, a compromise between covering as large a region as possible with the smallest feasible grid cells usually results in the selection of a grid boundary between 50 to 100 kilometers on a side, with a grid spacing of 2 to 5 kilometers (larger modeling regions and grid spacing may be required for regional applications). For CO modeling applications, a finer grid system covering less area than would be necessary for an ozone application is generally appropriate.

Since a number of factors not related to the emission inventory (e.g., meteorology) must be considered when defining the grid system, photochemical modeling specialists, local planning organizations, and meteorologists should be consulted before data collection begins to ensure that the selected grid system meets the general objectives of the modeling effort. Agencies involved in modeling adjacent areas (multi-State nonattainment areas, etc.) should coordinate selection of grid spacing, orientation, and origin.

Chapter 4 discusses the considerations and selection procedures mentioned above in greater detail.

2.2 DATA COLLECTION

Once the modeling region and grid system have been defined, collection of appropriate emission data can begin. Usually, point source, highway motor vehicle, and other area source emissions-related data are acquired separately. (Maintaining this distinction throughout the modeling inventory development process will generally prove useful, since it facilitates quality assurance and the construction of various inventories for evaluating control strategies and/or analyzing the sensitivity of model-predicted air quality parameters to emissions.) It is assumed that a conventional annual or seasonal county-level emission inventory, as described in Volume I, already exists, and that additional data must be collected as a basis for assigning emissions to grid cells, for determining temporal distributions, and for estimating the proportions of VOC and NO_x to be assigned to the chemical species or classes required in the model.

2.2.1 Existing Emission Inventories

Because many of the data requirements of the detailed emission inventory are quite resource-intensive, existing data and systems should be used whenever possible. Existing inventories, data handling systems, and planning models maintained by local agencies should be reviewed to determine what framework (if any) has already been established for handling emissions and related data, and what portions of this framework may possibly be utilized to develop the modeling inventory.

First, the existing emission inventory should be reviewed to determine what source and emissions data are already available. Most urban locations have VOC and NO_x inventories at the level of detail of EPA's Aerometric Information Retrieval System (AIRS), which has replaced the National Emission Data System (NEDS). If an accurate, comprehensive, and current inventory exists, then it can provide much of the basic data needed for the modeling inventory. If the existing inventory does not meet these criteria, it should be updated prior to or during the initial stages of modeling inventory compilation.

Additionally, the existing inventory should be examined to determine if it contains average annual emissions or has been adjusted to reflect typical emissions levels for the ozone season. If only annual emissions estimates are available, the inventory must be seasonally adjusted. Volume I discusses techniques for seasonal adjustment in detail; these techniques are also addressed herein in Chapters 5, 6, and 7 for point, area, and mobile sources, respectively.

The modeling region normally encompasses a number of counties. Because most counties do not have rectangular boundaries, portions of a county may extend beyond the boundaries of the modeling region. In this case, the existing county-level emission inventory must be examined to determine the emissions occurring within the modeling region.

The point source records included in most local emission inventories usually contain most of the data (including stack parameters and operating information) needed to construct the modeling inventory. The only necessary point source data not generally provided in such inventories are those dealing with speciation of VOC and NO_x emissions into chemical classes and detailed hourly emissions information. Likewise, most of the county-level area source activity levels in existing local inventories can be used as the basis for the modeling inventory, although spatial and temporal allocation factors will be needed to apportion county-level annual area source emissions to grid cells for each hour of the modeling episode.

The only important source category for which the existing inventory does not ordinarily represent a good starting point is highway motor vehicles. In annual and seasonal county-level inventories, highway motor vehicle emissions are often based on either gasoline sales or total vehicle miles traveled (VMT) for the county. These gross techniques do not provide the best available spatial resolution for photochemical modeling, so link-by-link traffic data for the area should be obtained from a transportation planning agency if possible.

2.2.2 Planning the Data Collection Effort

As discussed above, the existing inventories should contain much of the required information on total emissions for the area of interest. (Note, however, that many existing inventories have been compiled with respect to ozone precursor emissions; if photochemical modeling is being performed in support of a CO attainment demonstration, the existing inventory may need to be re-examined to ensure that all major sources of CO are included.) The documentation provided in support of the existing point source inventory (e.g., AIRS data) usually contains additional information on stack parameters for each source. The data collection effort in support of modeling inventory development should be directed toward providing the additional information required to (1) define the spatial distribution and temporal variations in emissions from each source or source category, and (2) assign VOC and NO_x emissions to appropriate chemical classes.

Ideally, emissions data (including VOC speciation information) would be available for each source for each hour of any day selected for modeling. In practice, however, this degree of detail is neither necessary nor practical for all sources because of the inordinate amount of effort required to secure such data and because, for many sources, inclusion of this data would have little effect on the ozone levels predicted by the photochemical model.

When planning the data collection effort, the agency responsible for compiling the modeling inventory must decide which apportioning information should be collected and which is unimportant (in other words, set priorities). For a typical urban region, emissions from highway motor vehicles, gasoline marketing and storage, solvent consumption, and power plants may account for much of the total VOC and NO_x in the inventory. The remaining VOC and NO_x emissions probably arise from a number of smaller sources, any of which individually has only a minor influence on predicted ozone levels even if small errors are made in allocating emissions from these minor sources to the proper grid cells or in estimating their seasonal and diurnal variations. By examining the existing inventory, the most important emission sources in the region can be identified; to minimize resource requirements, the data collection effort should focus on supplementing the existing spatial or temporal resolution data for these sources. Many sources emit such minor amounts of VOC and NO_x that little, if any, additional effort is warranted in gathering temporally and spatially resolved data regarding them.

Finally, the agency preparing the modeling inventory must work closely with the local metropolitan planning organization (MPO) or other planning agencies in the area to determine what transportation and land use planning models are currently being employed and what data from these models can be directly useful to the inventory compilation effort. In most urban areas where comprehensive transportation and land use planning are performed, much of the information needed to determine highway motor vehicle emissions, to make projections for future years, and to apportion emissions to the grid cell level will already be available.

2.2.3 Inventories of Pollutants Other than VOC, NO_x, and CO

The ozone modeling inventory development effort should be directed primarily toward obtaining accurate emission data for VOC, NO_x, and CO since these are the most important precursor pollutants in the photochemical production of ozone in urban atmospheres. For CO modeling, the focus is on CO inventories. Some photochemical models, such as the Urban Airshed Model (UAM), also have the capacity to accept emissions data and generate air quality estimates for other pollutants. This capability is provided primarily to allow these models to predict the effects of control strategies on ambient levels of these pollutants. Although sources of these pollutants should be included in the photochemical modeling inventory, developing spatially and temporally resolved emission estimates and projections for these sources is not warranted unless NO_x, VOC, and/or CO are also emitted in significant quantities.

2.2.4 Elevated Point Source Requirements

Some photochemical models, including the UAM, assign emissions from point sources to elevated grid cells if they are characterized by an effective stack height (i.e., the sum of the physical height of the stack and any plume rise) which is greater than the height of the grid cell. For these models, the emission inventory must include stack information (e.g., physical stack height and diameter, stack gas velocity, and temperature) for the major point sources in the area. The agency must therefore know whether the model it plans to employ requires data characterizing individual stacks. If required, the stack height used should be either the physical stack height or the Good Engineering Practice (GEP) stack height if the physical stack height exceeds the GEP stack height. As mentioned previously, the existing inventory will usually contain this information, and should be examined and utilized to the greatest extent possible in order to minimize additional costs to the modeling inventory effort.

2.3 PREPARATION OF THE MODELING INVENTORY

As mentioned in Section 2.2, three separate types of information not usually provided in the existing inventory will have to be added for modeling purposes. All three involve additional resolution of emissions, namely spatial, temporal, and chemical. The process of providing this additional resolution can be described as emissions modeling, since spatial, temporal, and chemical variations in emissions must be identified and applied to the existing inventory to fulfill the requirements of the modeling inventory. Accordingly, and also for reasons of brevity, the person (or persons) responsible for preparation of the modeling inventory will be referred to as the "emissions modeler" throughout this document.

2.3.1 Spatial Resolution of Emissions

In order for photochemical models to provide spatially resolved predictions of ozone and various other pollutants at the grid cell level, they must be supplied with emission data that have the same degree of spatial resolution; in other words, emissions must be resolved by grid cell. The amount of effort required to implement this resolution will vary depending on the type of source. Point source locations are typically reported to within a fraction of a kilometer in the existing inventory; hence, assigning emissions from these sources to the appropriate grid cell is simple. This assignment can be performed manually (by overlaying an outline of the grid system onto a map showing point source locations) or with the assistance of computerized routines.

By contrast, spatial resolution of area source emissions requires substantially more effort. Two basic methods can be used to apportion area source emissions to grid cells. The most accurate (and resource-intensive) approach is to obtain area source activity level information directly for each grid cell. The alternative approach, more commonly employed, is to apportion the county-level emissions from the existing annual inventory to grid cells using representative apportioning factors for each source type.

This latter approach requires the emissions modeler to determine apportioning factors based on the distribution of some spatial surrogate indicator of emission levels or activity (e.g., population, census tract data, or type of land use) for each grid cell and apply these factors to the county-level emissions to yield estimates of emissions from that source category by grid cell. The major assumption underlying this method is that emissions from each area source behave spatially in the same manner as the spatial surrogate indicator. In developing spatial apportioning factors, the emissions modeler should emphasize the determination of accurate factors for the more significant sources. In most large urban areas, local planning agencies can provide the emissions modeler with detailed land use, population or in some cases, employment statistics at the subcounty level; this data can be used to spatially apportion most of the area source emissions in the modeling inventory.

Highway motor vehicle emissions, which usually comprise a large fraction of total VOC and NO_x emissions, should be considered separately from other area sources in the modeling inventory. Instead of using county VMT or gasoline sales to estimate highway vehicle emissions (as annual and seasonal inventories sometimes do), urban transportation planning models should be employed to generate VMT on an individual link basis whenever possible. The emissions for each link could then be assigned to the appropriate grid cells.

Planning, land use, and transportation models are already in use in many urban areas, and can provide the emissions modeler with much of the data necessary to allocate area source emissions and develop emission estimates by link for highway motor vehicles. Such models are also generally capable of developing forecasts for future years which can be utilized in the development of projection inventories. Local agencies (particularly MPO's) should always be contacted during the inventory planning process to determine what planning models are being utilized and how the data available from these models can be used in the emission inventory effort. Obviously, trying to independently develop all the necessary information that should be available from the MPO requires much redundant effort on the part of the emissions modeler. Additionally, any subsequent photochemical modeling results might likely be challenged because of alleged nonconformity with other projections available to the public.

2.3.2 Temporal Resolution of Emissions

In order to predict hourly concentrations of ozone and other pollutants, photochemical simulation models require hour-by-hour estimates of emissions at the grid cell level. The emissions modeler can employ one (or more) of several approaches to provide the temporal detail needed in the modeling inventory. The most accurate and exacting approach is to determine the emissions (or activity levels) for specific sources for each hour of a typical day in the time period being modeled. This approach, while sometimes applicable to point sources, often proves impractical.

As an alternative, the emissions modeler can develop typical hourly patterns of activity levels for each source category, and then apply these to the annual or seasonally adjusted emissions to estimate hourly emissions. This approach is commonly employed for area sources, including highway motor vehicles, and is usually used for all but the largest point sources.

Usually, the photochemical air quality model is applied for an episode in the season of the year in which meteorological conditions are most conducive to ozone formation; for most locations, this means the summer months (i.e., June through August). By contrast, CO non-attainment episodes often occur in the winter months. Consequently, emissions must be adjusted to reflect typical levels for the particular non-attainment season (ozone or CO).

Similarly, emissions are usually adjusted to represent the day of the week on which polluting activities are at a maximum, normally a weekday. In some cases (such as validation studies), simulating weekend conditions when automotive and industrial emission levels are reduced may be useful. For this purpose, additional temporal pattern information pertaining to weekend days must be used to construct a weekend modeling inventory. Generally, however, the emissions modeler should not compile a weekend inventory unless (1) significant reductions or changes in emission patterns are expected; (2) the same inventorying procedures can be used as for weekdays, so that any resulting changes in predicted ambient ozone levels can be attributed to actual changes in precursor pollutant levels and patterns rather than simply to changes in methodologies; or (3) a significant number of ozone (or CO) exceedances occur on weekends. In many urban regions, the second will not be possible for highway vehicles, since transportation models are based on information (e.g., travel pattern surveys) applicable only for weekday situations. If the model is to be used to estimate ambient concentrations of various pollutants for time periods other than the ozone season, additional seasonal information may be required.

2.3.3 Chemical Resolution of Emissions

Because photochemical models are intended to simulate actual photochemistry, they utilize different chemistry for various types of VOCs and require specific information as to the proportions of these various types present in the inventory. For this reason, VOC emission totals must be disaggregated into subtotals for various chemical classes. NO_x emissions may also have to be distributed as NO and NO_2. (Some models do not require a NO_x breakdown because they assume all NO_x emissions to be NO.) Literally hundreds of individual chemical compounds typically compose the total VOC emissions in an urban area. No photochemical model considers each organic compound individually; instead, VOC emissions are distributed into chemical classes which behave similarly in photochemical reactions. The UAM employs a carbon bond classification scheme based on the presence of certain types of carbon bonds in each VOC molecule. Other models employ different classification schemes, which utilize different numbers and types of chemical classes.

The standard procedure for allocating VOC to chemical classes is to assume that the VOC emissions from each type of source contain a fixed percentage of each class of compound. This is the easiest of several methods that can be employed for allocating VOC emissions because the same VOC distribution is assumed to apply to each facility or process within a given source category.

In some instances, source-specific VOC species data may be available for certain individual facilities (perhaps through source tests or material composition considerations), and the emissions modeler may prefer to use these in the modeling inventory instead of an assumed VOC species distribution. Generally, however, most industries cannot provide reliable VOC or NO_x species data or accurately apportion their emissions into appropriate classes, in which case generalized VOC and NO_x distributions must be assumed for various source categories. Chapter 7 addresses development of representative VOC and NO_x "split factors" from the literature.

A potential problem when using generalized split factors to apportion VOC and NO_x into classes is that the source classification scheme (i.e., source category breakdown) employed in the inventory will probably not be directly compatible with the available split factor classification scheme in all cases. For example, the inventory may not distinguish between automotive exhaust and evaporative emissions, whereas different VOC split factors are typically available for each of these automotive emission components (and may be significantly different in some classification schemes.) As another example, many VOC classification schemes do not distinguish between different types of fuel combustion in external combustion boilers, yet most inventories do.

Hence, as part of the planning process, the emissions modeler should examine the split factors available for use and compare the classification thereof with the source classification scheme of the basic inventory. If serious inconsistencies exist for the more important VOC and NO_x source categories, the emissions modeler may need to consider modifying either or both of the classification schemes to minimize any resultant error. Alteration of the inventory source classification scheme may require significant resources and should be carefully evaluated prior to instituting such a change.

2.3.4 Special Considerations for CO Nonattainment Inventories

The 1990 Clean Air Act Amendments (CAAA) require the development, for each CO nonattainment area, of a CO emission inventory which addresses actual CO emissions during the peak CO season for the area. For many areas, the peak CO season will occur during the winter, necessitating the development of a winter inventory for CO modeling purposes. Most of the methods described in this document apply equally well to construction of modeling inventories for both ozone precursors and CO; a few special considerations for CO inventories, however, should be mentioned.

Ozone modeling episodes generally encompass several consecutive days; by contrast, CO simulations are usually applied for much shorter time periods (e.g., 8 to 16 hours). Consequently, accurate hourly allocation of emissions becomes more critical for CO simulations, and all temporal data for the inventory should be carefully evaluated for both accuracy and completeness. With regard to point sources, accurate and complete stack parameter data (see Section 2.2.4) are also required to ensure that CO emissions are appropriately allocated to the vertical layers of the modeling grid. As mentioned in Section 2.2.2, the existing inventory may need to be examined to ensure that all major CO sources are included. The grid resolution will also differ for CO and ozone simulations, with CO analyses using a finer grid system. Finally, if the existing inventory has been compiled for the ozone season, additional adjustments may be required to correct the emissions estimates to levels appropriate for the peak CO season.

For a more complete discussion of the CAAA requirements for CO and ozone nonattainment inventories, consult Emission Inventory Requirements for CO SIP Nonattainment Areas and Emission Inventory Requirements for Ozone SIP Nonattainment Areas (EPA, OAQPS, March 1991).

2.4 EMISSION PROJECTIONS

Regardless of the type of model employed, projection inventories are necessary to determine whether a given area will achieve or exceed the CO or ozone standard in future years. There are basically two types of projections: baseline projections and control strategy projections. Baseline projections are estimates of future year emissions that account for both expected growth in an area and air pollution control regulations that are in effect at the time the projections are made. Note that certain provisions in existing control regulations may take effect only at some future date, and baseline projections should include the effects of these expected changes. By contrast, control strategy projections also include the expected impact of revised or additional control regulations.

The concept of demonstrating "reasonable further progress" (RFP) was first introduced as part of the 1977 Clean Air Act Amendments. The 1990 CAAA have continued this requirement, whereby States, in order to monitor incremental air quality progress, must prepare annual RFP reports documenting estimated regional progress in meeting the policies, programs, and regulations of the adopted State Implementation Plan. Although annual RFPs are required, projected modeling inventories must be compiled only for Year 6 after enactment (i.e., 1996) and at three year intervals thereafter until attainment is demonstrated (the number of required modeling inventories varies with nonattainment status). The projected modeling inventories must be compiled using allowable emission rates as dictated by regulatory limits; these rates should be consistent with those used in the RFP tracking inventory for the year in question. Accordingly, the emissions modeler should confer with those persons responsible for RFP tracking to ensure consistency of projections and projection methodologies. EPA will be providing updated guidance on emission inventory projection techniques (to be released in July, 1991) and on RFP preparation (to be released in November, 1991).

In many respects, the baseline projection modeling inventory will be the same as the baseline projection inventory of annual or seasonal county-level emissions compiled for ozone nonattainment areas for use in models such as EKMA or to meet reasonable further progress requirements of the 1990 Clean Air Act Amendments. Both inventories will emphasize the same source categories and pollutants and utilize the same emission factors, activity levels, and control device data. Consequently, just as for the base year, the annual or seasonal county-level projection inventory may serve as a good starting point for developing the projection inventory used for modeling. However, as discussed in the preceding sections, incorporation of the spatial, temporal, and chemical resolution required by the model requires additional considerations on the part of the emissions modeler. These considerations, as they specifically relate to projection inventories, are listed below:

- The emissions modeler should consider anticipated changes in the spatial distribution of emissions from the base to projection years. Changes in point source emissions due to growth or control measures should be associated with specific locations within the modeling area, i.e., at either new or existing facilities. In this regard, pinpointing the location of any large point sources of VOC or NO_x that will be coming on line is especially critical. Apportioning factors for spatial allocation of area sources should reflect future land use patterns, employment, population, etc; while highway vehicle emission inventories should reflect changes in highway networks and driving patterns.

- Changes in temporal emission patterns should also be considered. Any anticipated changes in hourly, daily, or seasonal operating patterns between the base year and projection years should be reflected in the projection inventories.

- To the extent that VOC and NO_x split factors are expected to change between the base and projection year, such changes should be incorporated into the projection inventories.

Generally, of these three considerations, information will be most readily available concerning changes in spatial distribution. This is because local authorities and agencies should know projected locations of large, new point sources (at least in the near-term), and because highway vehicle and area source emission patterns will directly reflect changes in the land use, employment, and transportation data supplied by local planning agencies. With the exception of on-road motor vehicles, most of the temporal patterns and VOC and NO_x chemical class split factors will typically not be changed from the base year inventory either because no changes are expected or because no data will be available to forecast such changes. These considerations are discussed in more detail in succeeding chapters.

Of course, in some instances, baseline projection inventories of annual or seasonal county-wide emissions from the particular year of interest will not be available for use as starting points for the detailed, photochemical modeling inventories. Or, in other cases, the projection inventories that do exist may not reflect all of the growth and control scenarios that the agency may wish to evaluate with the photochemical model. In these situations, the emissions modeler will have to devote resources to the development of projection year inventories. Specific recommendations for making baseline projections are discussed in subsequent chapters. However, the following general considerations should be kept in mind from the outset of the inventory planning stages.

- To a large extent, projection inventories will be based on forecasts of industrial growth, population, land use, and transportation. The emissions modeler should not attempt to make these forecasts, but should rather rely on the local MPO or other planning agencies to supply them. This course of action has several advantages. First, duplicating the forecasts made by other planning agencies would be extremely costly. Second, emission projections should be based on the same forecasts utilized by other governmental planning agencies. This consistency is necessary to foster the credibility of any proposed control programs that are based on these emission projections.

- Control strategy projection inventories should be designed to reflect the control strategies being considered. This consideration may influence the type of data collected as well as the structure of the inventory itself. For example, if one of the modeling objectives is to evaluate the effect of applying Stage I controls only to service stations above a particular size cutoff, the emissions modeler may wish to treat these particular stations as point sources rather than lumping them in with a general service station area source category.

- All projection inventories should be based on the same methodologies and computation principles as the base year inventory. For example, if a traffic model is used for estimating travel demand for the base year, the same traffic model should be applied to estimate travel demand for projection years. Using the same methodology assures consistency between base year and projection year emission estimates and prevents the possibility of spurious inventory differences resulting solely from methodological changes.

- Projection inventories will always be subject to criticism because of their somewhat speculative nature. The technical credibility of emissions projections will be a function of their reasonableness, the amount of research and documentation of assumptions, and the procedures and methodologies used to make the projections. Some degree of uncertainty will always accompany emission projections; this fact should be acknowledged openly. When developing projection inventories, the emissions modeler should focus on minimizing instead of eliminating uncertainty. Internal and external review of the projection inventories will improve their technical quality and enhance their credibility.

2.5 DATA HANDLING

The large amount of data that must be gathered and stored in the inventory development effort and the complexity of developing spatially and temporally resolved emission projections generally requires a computerized data handling system. Ideally, as many data handling functions as possible should be computerized to allow devotion of more manpower resources to collection and analysis of the inventory data. A flow chart of the entire data handling operation, from the initial gathering of inventory data to the final development of a data file that is in the input format of the photochemical model being used, will prove useful to the emissions modeler in the operation of a computerized data handling system.

Many of the data handling functions are similar to those required for the existing inventory (e.g., data storage). Several additional data handling requirements arise during the development of the modeling inventory because of the additional spatial, temporal, and chemical resolution of this data.

As mentioned in Section 2.3.1, area source emissions are often spatially allocated to grid cells using apportioning factors. This step is usually computerized because of the large numbers of factors and calculations involved. Likewise, point source and highway motor vehicle emissions are usually assigned to the appropriate grid cells using computerized routines. For area and mobile sources, temporal variations will often be implemented by developing typical hourly activity patterns for each major source category. For many point sources, hourly activity levels can be reasonably inferred from the operating information supplied in the existing inventory. In either case, relatively simple algorithms can be developed and computerized to provide the necessary temporal resolution for the detailed inventory. VOC emissions are usually disaggregated into species classes through the use of an appropriate species distribution for each source category. NO_x emissions are either assumed to be all NO or are split into NO and NO_2. The allocation of VOC and NO_x emissions into classes involves straightforward calculations that should likewise be computerized.

One major data handling function involved in compiling the modeling inventory is the development of emission projections. Growth is typically accounted for by adjusting base year emissions in accordance either with projected changes in the emissions themselves or with changes in appropriate surrogate indicators of growth (e.g., earnings, population, land use, and employment). Control regulation and strategies can be reflected in an inventory by adjusting activity levels, control device efficiencies, or emission factors, as appropriate. The data handling system used should automate the development of growth and control-strategy projections as much as possible, thus minimizing the amount of manual effort needed each time a different scenario is modeled.

The final product of the modeling inventory development process is a file containing hourly gridded emissions estimates for each chemical class employed by the model. Because each model requires a special computerized format for the inventory data, utility programs will be necessary to convert the emission inventory file to a model-compatible format.

Of course, certain data handling functions, such as determining area source apportioning or growth factors, may not be supported by existing data handling systems. Thus, during the planning stages, the emissions modeler must carefully review the data handling flow chart to determine which activities can be done by computer and which functions must be performed manually. Specific data handling requirements and EPA systems that support these requirements are addressed in subsequent chapters.

2.6 RESOURCE REQUIREMENTS

Staffing and expertise requirements should be considered as part of the planning process. Depending on the status of the existing inventory and the amount of additional detail required, compilation of a modeling inventory can require from 500 to 5,000 staff hours. The low estimate is for a case in which a gridded or very complete county-level inventory already exists, and the region is dominated by only a few major types of sources. The high estimate is for a case in which little or obsolete inventory information is available and the region has many significant sources, requiring detailed analysis of all significant sources and considerable individual contact with managers of specific sources.

In addition to those staff usually responsible for compilation and maintenance of emission inventories, the agency should enlist the services of (1) a photochemical modeling specialist familiar with the operation and the VOC species classes of the particular photochemical model to be used, (2) a computer programmer or systems analyst to plan the storage and manipulation of the large amounts of emission data needed, and (3) an urban or regional planner to analyze transportation and land use data from local planning agencies and to assist the emissions modeler in making emission projections.

2.7 OVERVIEW OF EMISSION INVENTORY PLANNING PROCEDURES

The remaining sections of this document present detailed "how-to" procedures for producing a modeling inventory. Specific topics addressed include

- defining the grid system (Chapter 4);
- collecting and compiling data from point, highway motor vehicle, other area, and biogenic sources, including information regarding spatial and temporal resolution (Chapters 5, 6, 7, and 8, respectively);
- allocating VOC and NO_x emission data into chemical classes (Chapter 9); and
- data handling requirements for each of these procedures (discussed individually in each chapter).

Prior to initiating the data collection phase of the emission inventory effort, the agency should be able to answer "yes" to the following questions:

- Has the size and orientation of the grid been defined? Has the grid cell size been defined? Have the decisions been coordinated with agencies involved in modeling exercises for adjacent areas?
- If a detailed emission inventory has been developed, have hourly emissions been summed to estimate daily county emission totals (e.g., link based data)?
- Have the time periods (i.e., month, day, year) been specified for which the emission inventory must apply?
- Has the existing emission inventory been reviewed to determine what data can be utilized in the photochemical modeling inventory, and what additional temporal and spatial data must be gathered?

- Does the agency know what VOC and NO_x classifications are needed by the particular photochemical model that will be run?

- Are the source categories required in the photochemical modeling inventory (in order to reflect specific control strategies and to be consistent with available VOC split factor information) compatible with those in the existing annual or seasonal inventory?

- Have the appropriate State and local transportation and planning agencies been contacted to determine what baseline and projection data on traffic, employment, population, etc., are available for use in the detailed inventory?

- Will the detailed emission inventory be utilized for modeling pollutants other than ozone? For other seasons than the summer? Are additional or better-resolved source and emissions data needed for these other uses?

- Are the existing inventory files and data handling systems capable of generating and storing the additional temporal, spatial, and VOC and NO_x classification data required by the photochemical model? Can the model-compatible emissions file be readily generated from the resulting point, line, and area source and emission files? Are sufficient stack data available to distinguish elevated point sources from ground level point sources?

- Are sufficient resources available to complete both the base year and projection inventories, considering both growth and control strategy options?

Addressing these issues at the outset of the modeling inventory development process will limit the number of difficulties arising from poor planning rather than data limitations.

3 OVERVIEW OF THE URBAN AIRSHED MODEL (UAM) AND THE UAM EMISSION PREPROCESSOR SYSTEM

3.1 INTRODUCTION

In 1984, the EPA's Office of Air Quality Planning and Standards proposed that the Urban Airshed Model (UAM) be a "recommended" (i.e., preferred) model for "photochemical pollutant modeling applications involving entire urban areas." EPA finalized this recommendation in 1986, noting that the UAM "is the most widely applied and evaluated photochemical model in existance." Currently, the UAM is the recommended air quality simulation model for use in ozone air quality analyses in the preparation of State Implementation Plans (SIP) as required in the 1990 Clean Air Act Amendments (CAAA).

Accordingly, this document addresses the development of an emission inventory suitable for photochemical modeling in terms of the specific requirements of the UAM. As noted previously, however, the techniques and types of data necessary to generate the UAM emission inventory inputs are generally suitable for developing an emission inventory for use with any photochemical model.

3.2 CONCEPTUAL OVERVIEW OF THE URBAN AIRSHED MODEL

The UAM is a three-dimensional photochemical grid model designed to calculate concentrations of both inert and chemically reactive pollutants by simulating physical and chemical processes which occur in the atmosphere. These calculations are based on the atmospheric diffusivity or species continuity equation, which represents a mass balance in which all relevant processes (precursor emissions, transport, diffusion, chemical reactions, and removal processes) are expressed in mathematical terms. For ozone assessment, the model is usually applied for a 36- to 72-hour period during which adverse meteorological conditions result in elevated concentrations. For carbon monoxide simulations, the model is usually applied for shorter time periods (e.g., 8 to 16 hours).

Major factors affecting photochemical air quality include:

- spatial (vertical and horizontal) and temporal distribution of anthropogenic and biogenic emissions of NO_x, VOC, and CO;

- chemical composition of the emitted NO_x and VOC;

- spatial and temporal variations in wind fields;
- dynamics of the boundary layer, including stability and mixing;
- chemical reactions involving VOC, NO_x, CO, and other important species;
- diurnal variations of solar insolation and temperature;
- loss of ozone and ozone precursors by dry deposition; and
- ambient background concentrations of VOC, NO_x, CO, and other species in, immediately upwind of, and above the study region.

In a UAM application, these processes are simulated for the pollutant of interest (this may be either summertime ozone concentrations or wintertime carbon monoxide concentrations). The UAM solves the species continuity equation for each time step, in each grid cell of the modeling domain; the maximum time step is a function of grid size and the maximum wind velocity. Typical time steps for urban-scale simulations are on the order of 3 to 6 minutes.

Since the UAM accounts for spatial and temporal variations as well as reactivity differences (speciations) of emissions, it is ideally suited for evaluating the effects of emission control scenarios on urban air quality. In practice, a historical ozone (or carbon monoxide) episode is replicated to establish a base case simulation. Model inputs are prepared from observed meteorological, emission, and air quality data for a particular day or days. The results of the UAM simulations are examined in the model performance evaluation. Once the results have been evaluated and determined to perform within prescribed levels, a projected emission inventory that includes changes in emissions due to proposed control measures is used with the same meteorological inputs to simulate possible future emission scenarios (in other words, the model will calculate hourly ozone patterns likely to occur under the same meteorological conditions as the base case).

3.3 OVERVIEW OF THE UAM EMISSION PREPROCESSOR SYSTEM

To facilitate cost-effective development of the detailed emission inventories required by UAM, the EPA's Office of Air Quality Planning and Standards sponsored development of a system of computer programs designed to perform the intensive data manipulations necessary to adapt a county-level annual or seasonal emission inventory for photochemical modeling use. This system, the UAM Emission Preprocessor System (EPS), is available to the public from EPA. Although the UAM EPS was originally developed for use with an annual average inventory similar in format to NAPAP, many of its functions and procedures can be adapted for use with similar annual or seasonal emission inventories.

The UAM EPS consists of six FORTRAN programs which are executed sequentially on a large computer mainframe system (some of the programs in the EPS can be adapted for use on PCs or workstations) to generate the emission input files for the UAM. To execute the UAM EPS, the following steps must be performed:

- Define the modeling region of interest. Identify grid origins (UTM coordinates), resolution of the grid, cell size, number of cells in the x and y directions, and the dates to be simulated. Discuss with the air quality modeler the number of vertical layers to be modeled, the number of vertical layers below and above the mixing height, and the minimum layer thickness.

- Determine the plume height cutoff, which will be used to determine which point sources will receive elevated (i.e., vertically resolved) treatment by the model. For guidance on selection of an appropriate plume height cutoff, consult Guideline for Regulatory Application of the Urban Airshed Model.[2]

- Run the EPA mobile source emission factor model MOBILE 4.1 to estimate mobile source emission factors based on vehicle fleet mix for the specific area to be modeled.

- Develop relationships between roadway links and grid cell coordinates (optional).

- Develop spatial surrogate indicator data for allocating area sources to grid cells.

- Prepare an inventory of biogenic emissions suitable for photochemical modeling as described in Chapter 8.

For more information of accomplishing these steps, refer to the following EPA guidance documents:

- Guideline for Regulatory Application of the Urban Airshed Model (EPA-450/4-91-013, June 1991),

- User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System (EPA-450/4-90-007D, June 1990), and

- User's Guide to Mobile 4.1 (Mobile Source Emission Factor Model) (EPA-AA-TEB-91-01, June 1991).

Figure 3-1 shows an overview of the UAM EPS; Figures 3-2 through 3-7 contain flowcharts of the input and output files for each program in the UAM EPS. Note that the

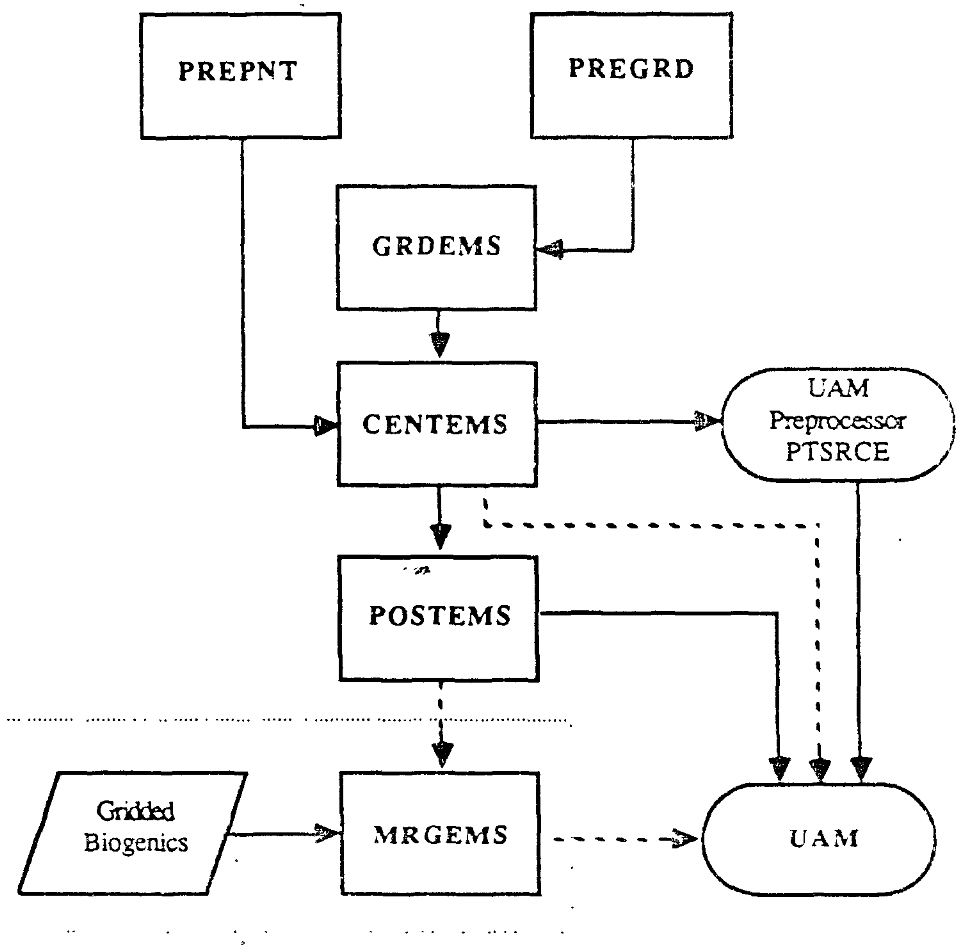


FIGURE 3-1. Overview of the UAM emissions preprocessor system.

UAM preprocessor PTSRCE must be executed subsequent to the UAM EPS to prepare the final UAM elevated point source input file before modeling. The six routines and their primary functions are briefly described below. For a detailed description of the UAM EPS and its input file formats, see the User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System.[3]

PREPNT. The PREPNT program (Figure 3-2) prepares the annual average or seasonal point source inventory for chemical speciation by the CENTEMS module. Latitudinal and longitudinal coordinates for each source are converted to Universal Transverse Mercator (UTM) coordinates, which are in turn converted to modeling region grid cell coordinates. Each source is assigned a stack identification code and the emissions allocated by stack. Temporal distribution profiles are assigned based on the operating information contained in the annual or seasonal inventory. PREPNT also calculates a plume rise for each stack based on the Briggs effective height calculation, using the stack parameters contained in the annual or seasonal inventory and default meteorological conditions; the value of this plume rise determines if stacks will be treated as elevated or low-level sources by subsequent programs in the UAM EPS.

PREPNT requires four input files:

(1) a user input file, containing information on the plume rise cutoff for elevated treatment, default stack parameters, and optional emission control factors for each pollutant by Standard Industrial Classification (SIC) code;

(2) projected industrial growth factors by two-digit SIC code;

(3) a file defining the modeling region, which specifies the modeling grid (UTM origin, UTM zone, and number and size of grid cells), number of counties within the modeling region, FIPS and AEROS identification codes for each county, and control codes by county indicating the presence of Inspection and Maintenance and Stage II Vapor Recovery control programs; and

(4) the annual or seasonal point source inventory, including source identification codes, location, stack parameters, operating schedule information, and emissions.

In addition to miscellaneous informative outputs, PREPNT produces two files which undergo subsequent processing in the CENTEMS module: a gridded point source inventory in Model Emissions Record Format, or MERF (Table 3-1), and a control file containing parameters for the stacks selected for elevated source treatment.

PREGRD. The PREGRD program (Figure 3-3) reformats an annual or seasonal area source emission inventory and prepares it for gridding. Emissions are separated into two files,

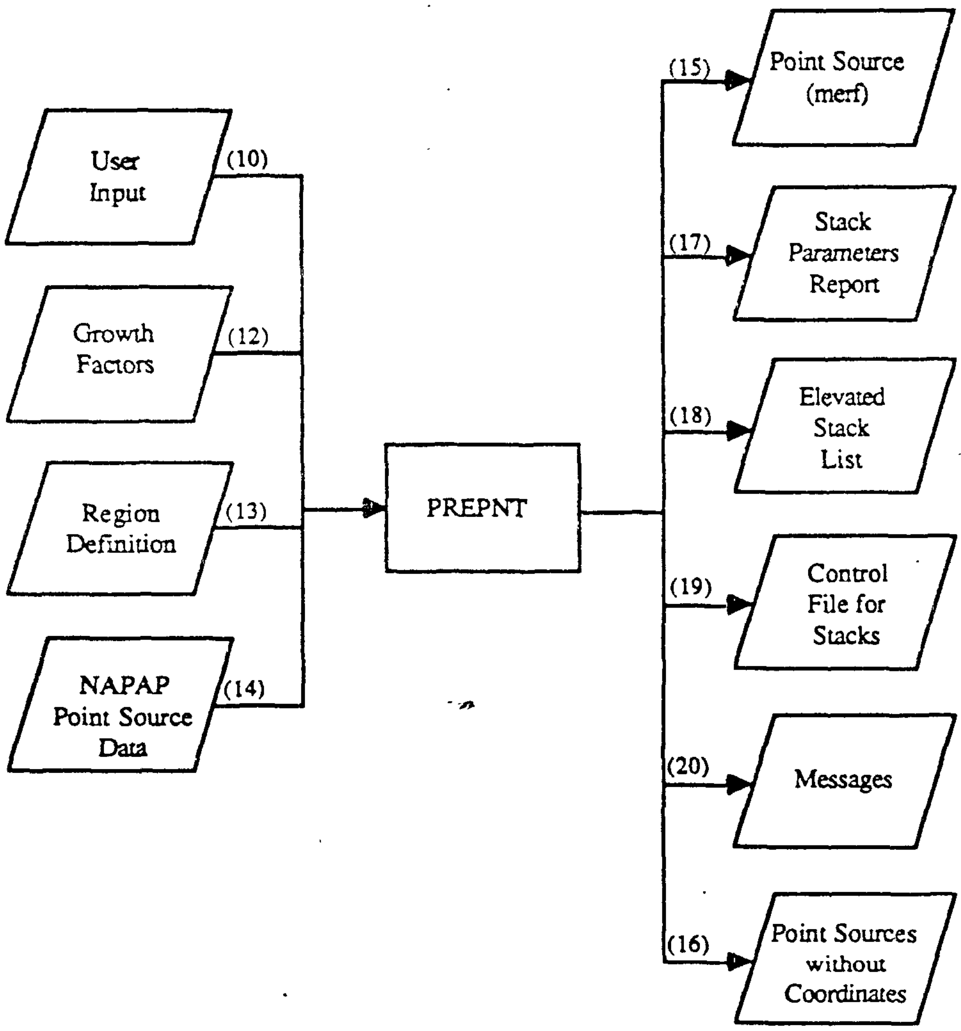


FIGURE 3-2. Input and output files used by PREPNT. (Numbers in parentheses refer to FORTRAN units used.)

TABLE 3-1. Standard Modeling Emissions Record Format (MERF) employed by the UAM Emissions Preprocessor System.

Variable	Columns	Type	Description
ISRG	1-3	I	Gridded surrogate code (not used, skipped)
IFIP	4-8	I	FIPS state/county code (not used, skipped)
SIC	9-12	R	Either Source Industrial Classification or Area Source Category code
SCC	13-20	A	Either Standard Classification Code or Area Source Category code
ICL	21-23	I	I coordinate of grid cell
JCL	24-26	I	J coordinate of grid cell
IYR	27-28	I	Year, two digits (e.g., 89 for 1989)
IDYCOD	29-30	I	Diurnal variation code
IWKCOD	31-32	I	Weekday variation code
FID	33-41	A	Facility ID (0 or blank for area sources)
FST	42-46	A	Stack ID (0 or blank for area sources)
FCNTY	47-52 53-56	I -	AEROS state/county code (Not used, skipped)
VMNTH	57-116	R	Array of 12 monthly factors
CO	117-126	R	CO episode emissions (kg/day)
CNO	127-136	R	NO_x episode emissions (kg/day)
SOX	137-146	R	SO_x episode emissions (kg/day)
THC	147-156	R	THC episode emissions (kg/day)
PM	157-166 167-168	R -	PM episode emissions (kg/day) (Not used, skipped)
SLBL	169-175	A	Scenario label (not used, skipped)

Sample MERF Record:

```
361230400150 12 29  24 5    0016   1110380   0 0830 0830.0830.0830 0830 0830.0830 0830 0830.0830 0830.083    0.00    0.00    0 00   302 48    0 00
```

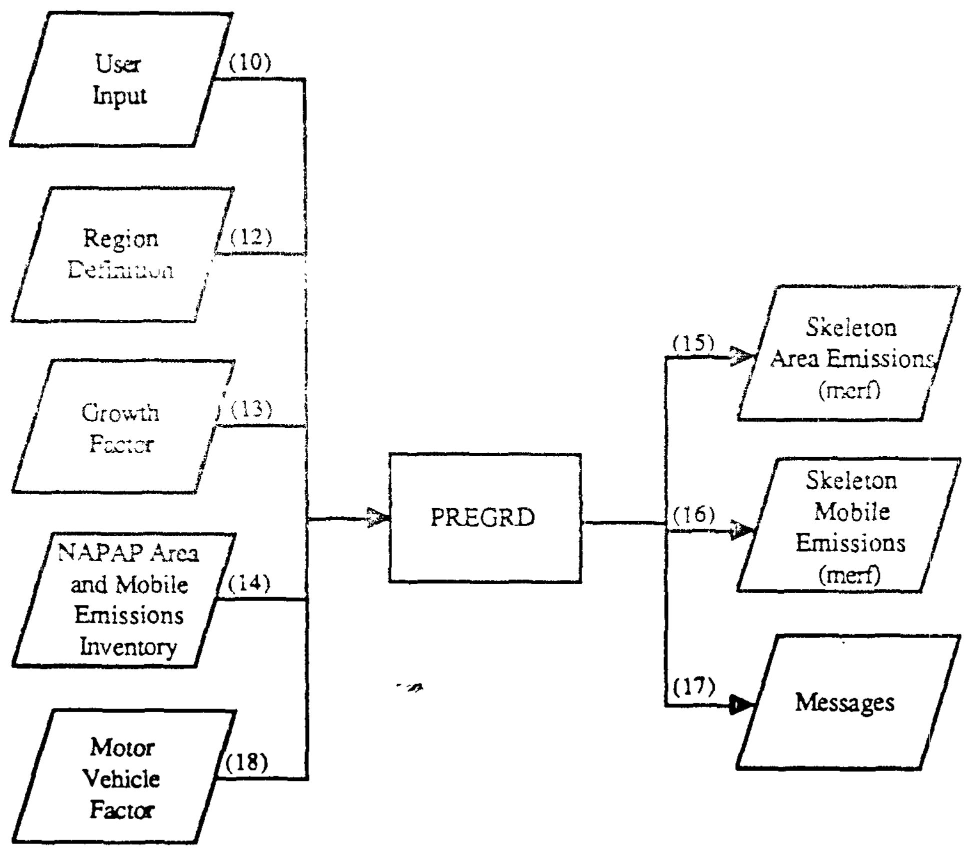


FIGURE 3-3. Input and output files used by PREGRD.

area sources and on-road motor vehicle sources. Emissions from on-road motor vehicles are disaggregated into exhaust, evaporative, refueling, and running loss components.

PREGRD requires five input files:

(1) a user input file, containing fractions of vehicle miles traveled (VMT) by gasoline-fueled vehicle type which are used in allocating refueling emissions, a flag indicating a weekday or weekend modeling episode, and an optional list of additional control factors for each pollutant by source category code;

(2) a region definition file (this is the same file used by PREPNT);

(3) projected growth factors by source category code;

(4) a file containing motor vehicle adjustment factors used to adjust annual or seasonal average mobile source emissions for episodic conditions; and

(5) the annual or seasonal area source inventory, containing county-level emission estimates by source category.

The area source and on-road motor vehicle MERF files generated by PREGRD for input into GRDEMS contain incomplete records, with grid cell indexes and other fields left blank.

<u>**GRDEMS**</u>. The GRDEMS program (Figure 3-4) allocates the pre-processed county-level emissions from PREGRD to the modeling region grid cells based on a gridded spatial apportioning factor field and optional link data (e.g., limited access roads, railways, etc.). Temporal distribution profiles are assigned by source category.

GRDEMS requires six input files:

(1) a user input file, containing a description of the run, the year of emissions, a unit conversion factor, and optional pairings of surrogates and source categories by county to override the pairings contained in the cross-reference file;

(2) a region definition file (the same file used by PREPNT and PREGRD);

(3) a cross-reference table of spatial surrogate codes and diurnal distribution profiles by source category;

(4) the gridded spatial surrogate file;

(5) an optional data file specifying link locations for the modeling region; and

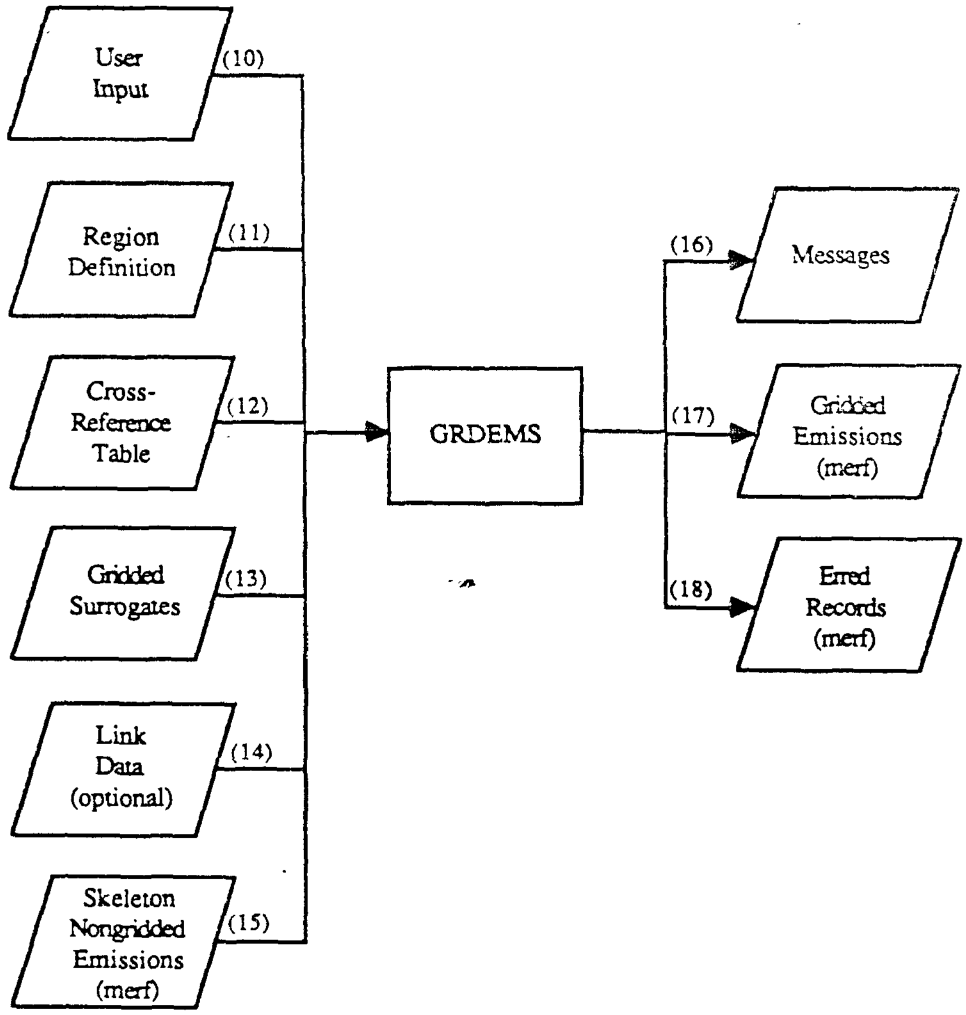


FIGURE 3-4. Input and output files used by GRDEMS.

(6) the county-level MERF emissions file(s) generated by PREGRD.

GRDEMS produces a gridded MERF emissions file for further processing by the CENTEMS program. Although the separate area and mobile source emissions files from PREGRD can be merged before running GRDEMS, processing these files separately through GRDEMS allows better tracking of emissions totals and quality control.

CENTEMS. CENTEMS (Figure 3-5), the central program of the UAM EPS, creates a gridded low-level binary emissions file in UAM-format and an elevated point source input file for the UAM preprocessor program PTSRCE. Annual average daily emissions are adjusted to account for monthly variations and assigned to the hours of the modeling episode based on temporal distribution profiles. Total hydrocarbon emissions are speciated into Carbon-Bond (CB-IV) classes using EPA VOC speciation profiles by either Source Classification Code (SCC) for point sources or EPA Area Source Category Code.

In addition to the MERF emissions files from PREPNT and GRDEMS, CENTEMS requires the following inputs:

(1) a user-input file, containing information on the type of sources, time and day flags for the modeling episode, modeling region information, and control factors;

(2) the elevated point source parameter control file created by PREPNT;

(3) a glossary file matching SIC/SCC combination (for point sources) or EPA Source Category (for area or mobile sources) with the activity, process, control, and inventory source category codes used for tabulation of emissions totals;

(4) a speciation factors file, containing carbon-bond speciation factors in terms of moles/gram by EPA VOC speciation profile code;

(5) a speciation profile file, which assigns EPA VOC speciation profiles based on SCC (for point sources) or EPA Source Category (for area and mobile sources);

(6) a diurnal variation factors file, containing hourly profiles for the diurnal codes contained in the MERF files, which are used to allocate the daily emissions to the hours of the modeling episode; and

(7) a weekday factor file for adjusting emissions based on the day of week by the weekday code in the MERF record.

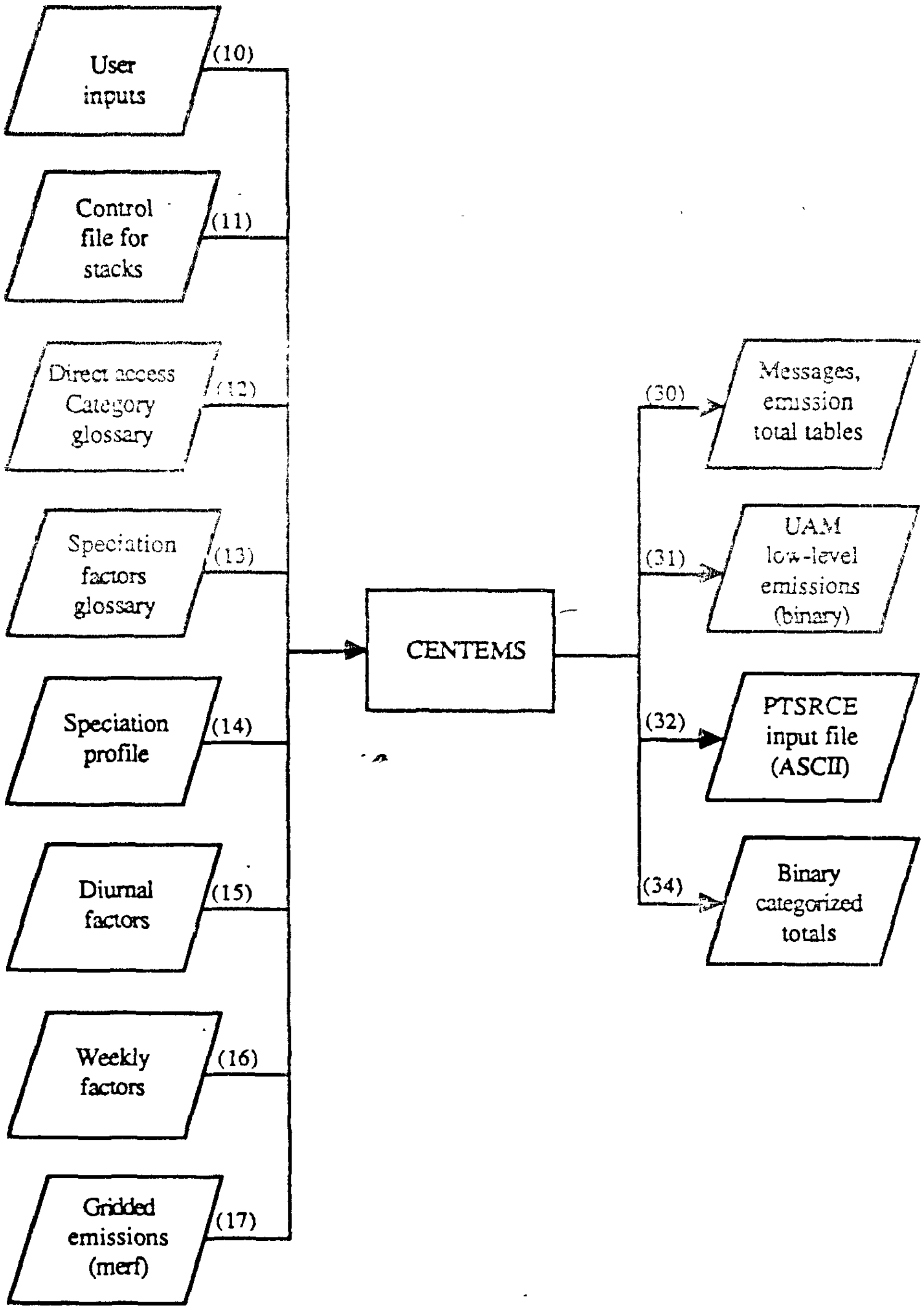


FIGURE 3-5. Input and output files used by CENTEMS.

CENTEMS produces the low-level UAM emissions file and the elevated point source file mentioned above as well as a binary file of categorized emissions totals for input to the POSTEMS module.

POSTEMS. The POSTEMS program (Figure 3-6) merges up to six ground-level anthropogenic UAM emission files into one file. POSTEMS also provides summary printouts describing emission totals by activity, process, control, and inventory source category codes.

The input files for POSTEMS include the following:

(1) a user input file specifying the Julian date for the final merged UAM emissions file, the number of files to be merged, user-selected options, UAM header record information, and the types of emissions in the input files;

(2) five input files defining the codes contained in the binary file of categorized emissions totals produced by CENTEMS;

(3) a chemical species data file, containing information about the molecular organic species in the emission inventory; and

(4) up to six low-level UAM emissions files and the corresponding binary categorized totals files from CENTEMS.

MRGEMS. The MRGEMS program (Figure 3-7) merges two low-level UAM emissions files into one file. Generally, this program is used to merge the anthropogenic emissions file created by POSTEMS with a biogenic emissions file (in UAM format) generated by another program, such as BEIS (described in Chapter 8).

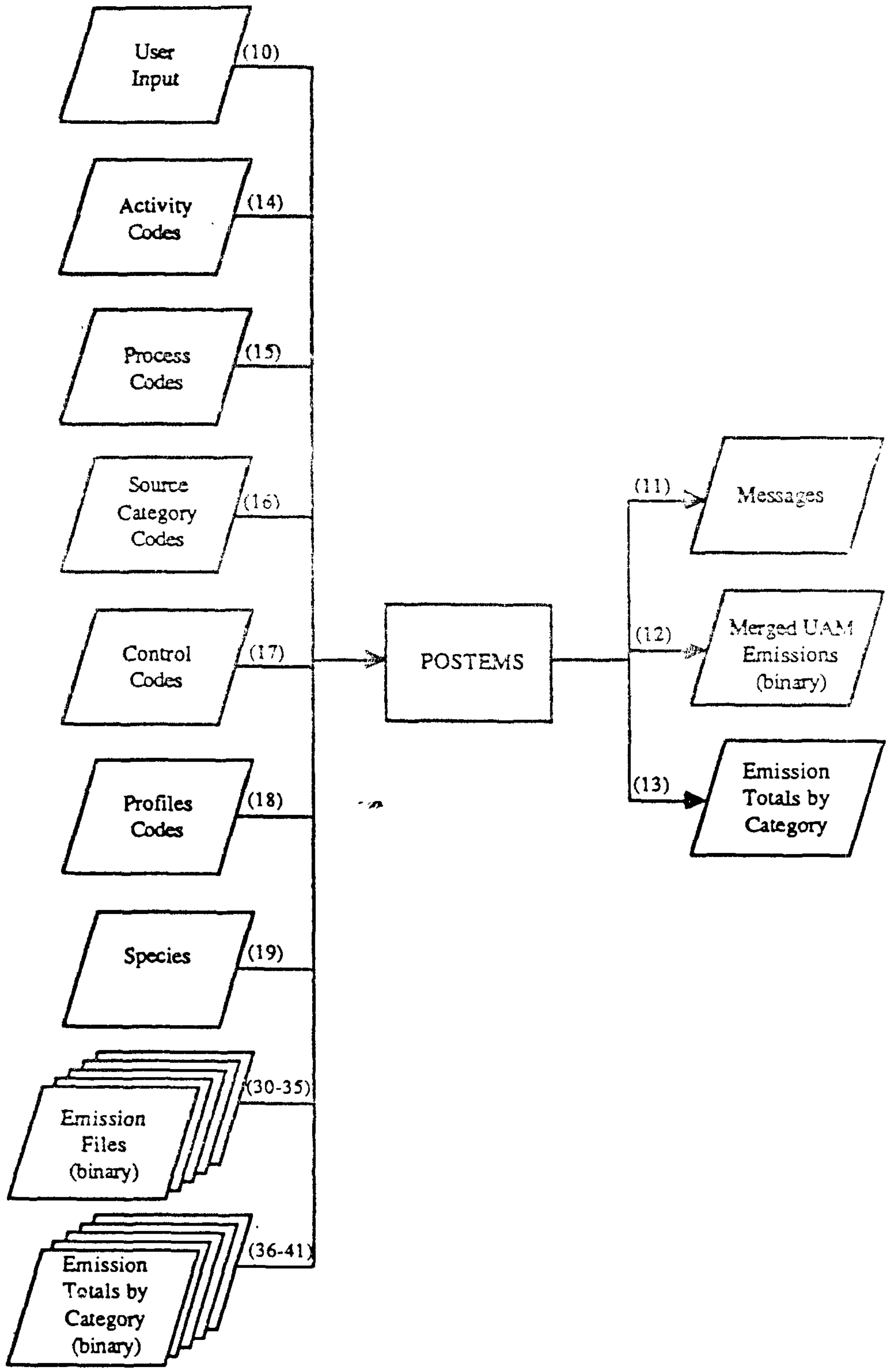


FIGURE 3-6. Input and output files used by POSTEMS.

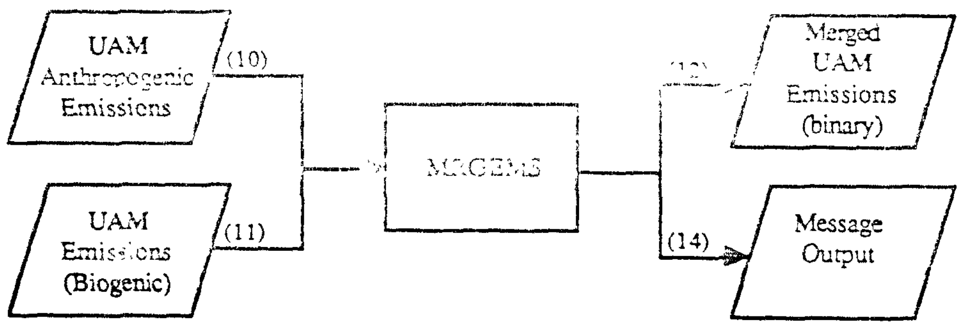


FIGURE 3-7. Input and output files used by MRGEMS.

References for Chapter 3

1. User's Guide for the Urban Airshed Model, Volume I: User's Manual for UAM (CB-IV), EPA-450/4-90-007A, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1990.

2. Guideline for Regulatory Application of the Urban Airshed Model, EPA-450/4-91-013, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1991.

3. User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System, EPA-450/4-90-007D, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1990.

4 DETERMINATION OF THE GRID SYSTEM

4.1 SELECTING AN APPROPRIATE GRID SYSTEM

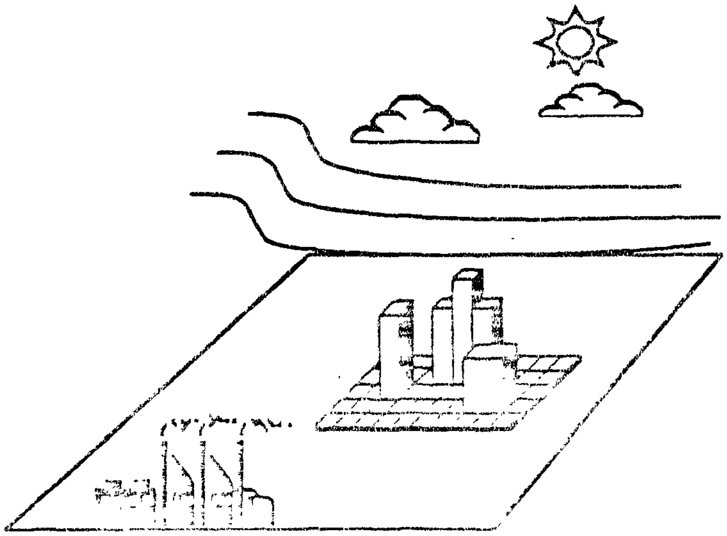
Identification of the grid system which will be used to spatially reference emissions in the modeling inventory influences all subsequent phases of the emission inventory process. This chapter has been included to provide a general discussion of issues of concern in selection of the modeling region and grid system. For definitive guidance concerning establishment of the grid system, however, consult the Guideline for Regulatory Application of the Urban Airshed Model.[1]

The first step in defining the grid system is selection of a grid boundary outlining the area to be modeled. Once the grid boundary has been chosen, the region enclosed by the grid boundary (subsequently referred to as the "modeling region" in this text) must be subdivided into grid cells. Figure 4-1 illustrates the concepts of grid boundary and grid cells. The UAM is a three-dimensional grid model, capable of resolving emissions vertically as well as horizontally. For purposes of compiling the modeling emissions inventory, however, emissions need only be resolved over a horizontal grid system; the UAM will automatically allocate emissions from those sources selected to receive elevated treatment to the appropriate vertical layer based on the stack parameters for each source and meteorological conditions. Accordingly, in the following discussion, the term "grid" will refer to a two-dimensional grid system overlaying the area to be modeled.

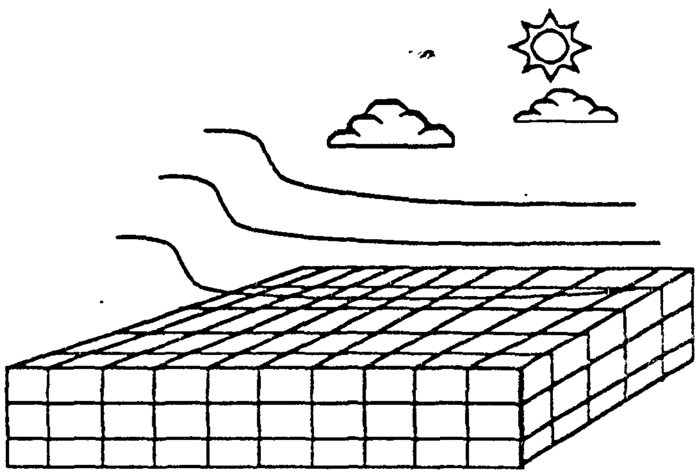
Almost always, the grid boundary will be rectangular and the grid cells will be equally-sized squares. Selection of an appropriate grid system involves consultation with planning agencies, air pollution control agencies, meteorologists, and photochemical modeling specialists to ensure that the chosen grid system meets the general objectives of the photochemical modeling program.

The modeling inventory must spatially resolve emissions in terms of the individual grid cells comprising the modeling region. A typical grid system will cover thousands of square kilometers and contain hundreds of grid cells.

- Figure 4-2 shows an example grid system. In this figure, a 4 km x 4 km modeling grid has been superimposed over a map of the St. Louis, Missouri area. This grid consists of 15 grid cells in the east-west direction and 20 cells in the north-south direction for a total of 300 individual grid cells, each 16 square kilometers in size. The total area encompassed by the grid boundary is 4,800 square kilometers.



(a) The Area to Be Modeled



(b) Specification of the Grid

FIGURE 4-1. Schematic illustration of the use of the grid in the Urban Airshed Model.

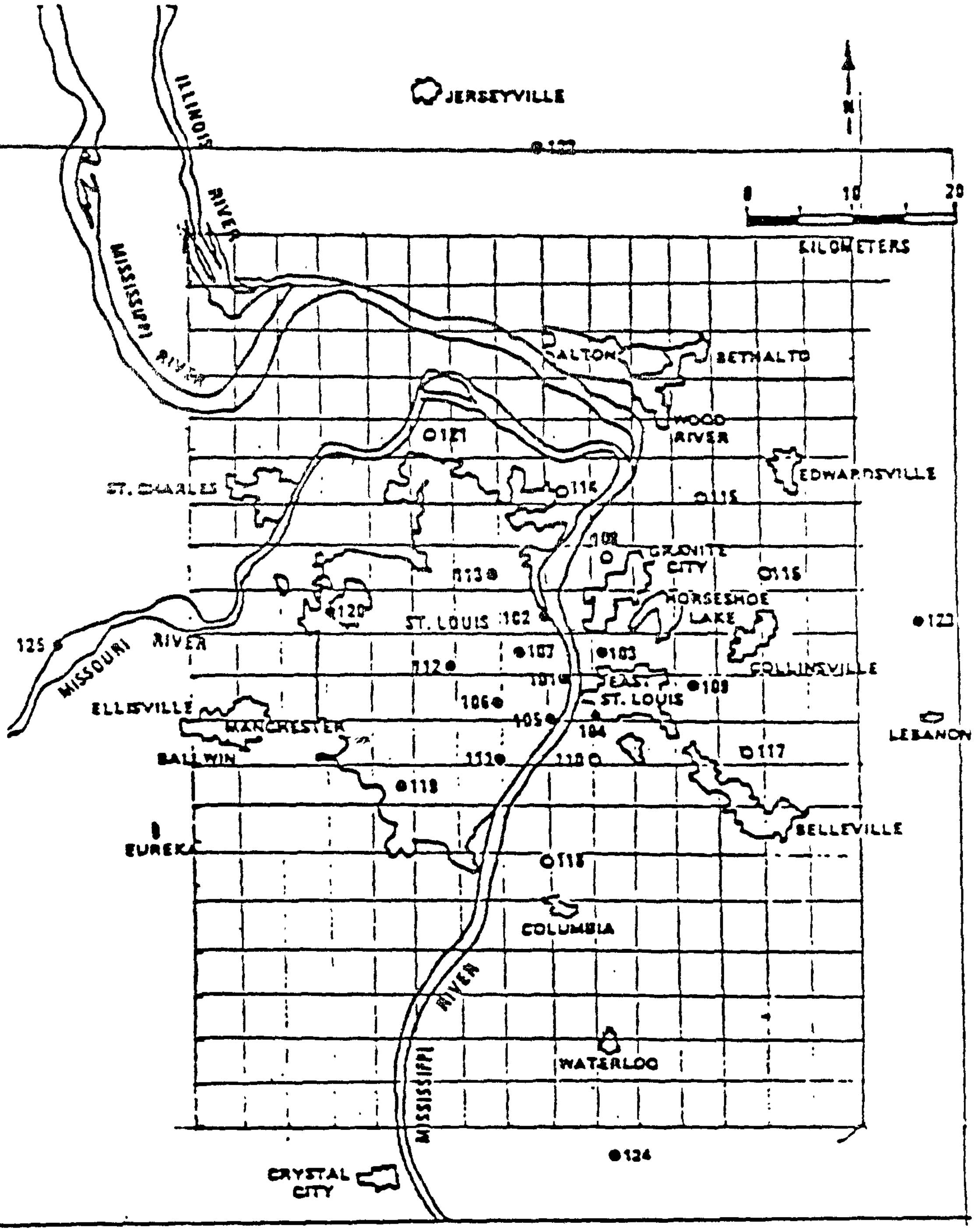


FIGURE 4-2. The St. Louis Area with locations of the RAPS surface stations and 4 km x 4km modeling grid superimposed.

Obviously, since emissions must be determined for each grid cell in the modeling region, an appropriate grid system should be developed at the outset of the emission inventory effort which defines both the overall size and shape of the grid to be modeled and the size and number of grid cells that compose the grid. Defining the grid system before beginning the modeling inventory development process will help minimize redundancy of effort.

4.1.1 Area Covered by the Grid System

The selection of the modeling region should reflect location of sources of meteorological and air quality data, location of current and expected major emissions sources, and types of control strategies under consideration. The photochemical reactions resulting in ozone formation can occur many miles downwind of precursor pollutant sources. Accordingly, the modeling region must be fairly large to ensure that all major emission sources which may affect ozone formation in the urban area are included.

The modeling region should contain as many ozone and precursor pollutant monitoring stations as possible to facilitate model validation. The model validation process entails simulating an historical ozone episode to determine if the observed ozone and precursor pollutant concentrations at each monitoring station agree with the concentrations predicted by the model. In the validation process, ambient air measurements are used to define pollutant concentrations along the boundary of the modeling region.

Additionally, the modeling region should be large enough to encompass areas of current limited land use activity that are expected to develop significantly as a result of projected growth. Since an important application of photochemical models is evaluation of expected ozone concentrations in future years, the emissions modeler should consult land use planners to determine what types of growth are expected and in what areas.

The modeling region should also be large enough to encompass the effects of meteorology in the modeling region. Since peak ozone levels often occur downwind of the urban center, as much "downwind area" as possible should be included in the modeling region so that the model can predict where and when these peak levels will occur. Selection of a large modeling region also minimizes the possibility that receptor locations will be impacted by air parcels that have left the domain and then re-entered it because of shifting meteorological conditions during the time interval over which the model is run.

Finally, to reduce the dependence of model predictions on uncertain boundary conditions (e.g., the pollutant concentrations assumed along the boundary of the modeling region), the modeling region should extend into areas with little or no emissions. Of course, in certain areas (e.g., the Northeast United States), pollutant transport from nearby urban areas may preclude the possibility of a clean background along any boundaries that may be chosen.

If the selected modeling region covers too large an area, however, certain problems may occur in gathering and manipulating data. For instance, the modeling region may extend into areas for which detailed spatially and temporally resolved emission estimates cannot be made due to lack of adequate information. This might be the case if one part of the domain lies within the jurisdiction of a metropolitan planning organization (MPO) and another part lies within an outlying, undeveloped jurisdiction. Detailed records and projections will probably be available for the metropolitan areas, but may not exist for the outlying area. Technical problems may also be encountered if various jurisdictions within the modeling region maintain information in different [illegible] maintain records for townships and use EPA's Aerometric Information Retrieval System (AIRS), whereas another area may maintain records for census tracts and use a locally developed data handling system that is incompatible [illegible]

If the exact area for which the photochemical model will be applied is not initially known, perhaps because of uncertainties about future land use or the effect of meteorological conditions, the emission inventory development process can still proceed. In this case, the emissions modeler must choose an emissions grid system for which to compile emissions data. In general, the area encompassed by the emissions grid should be as large as possible. A smaller area can then be selected for photochemical modeling within the emissions grid with no additional emission data collection effort required. Thus, the emissions grid can be larger than the actual grid used for modeling. For most efficient use of time and resources, however, the emissions grid and the modeling region should coincide.

The modeling region is normally rectangular. Some models, including the UAM, may accept an irregularly shaped modeling region. Even if the modeling region is irregularly shaped, however, a rectangle should be used for the boundary of the emissions area for the sake of simplicity and ease in locating grid cells. The forcing of a rectangular boundary around an irregularly shaped city may mean that some of the peripheral grid cells may contain zero emissions. For example, coastal cities usually have portions of the ocean included within the rectangular grid boundary, as shown in Figure 4-3.

4.1.2 Grid Cell Size

The degree of spatial resolution of the modeling emission inventory must also be decided during the initial planning stages of the inventory effort. Choice of an appropriate grid spacing depends on the overall modeling objectives, the total area of interest, the amount of manpower available, and the cost of running the photochemical model.

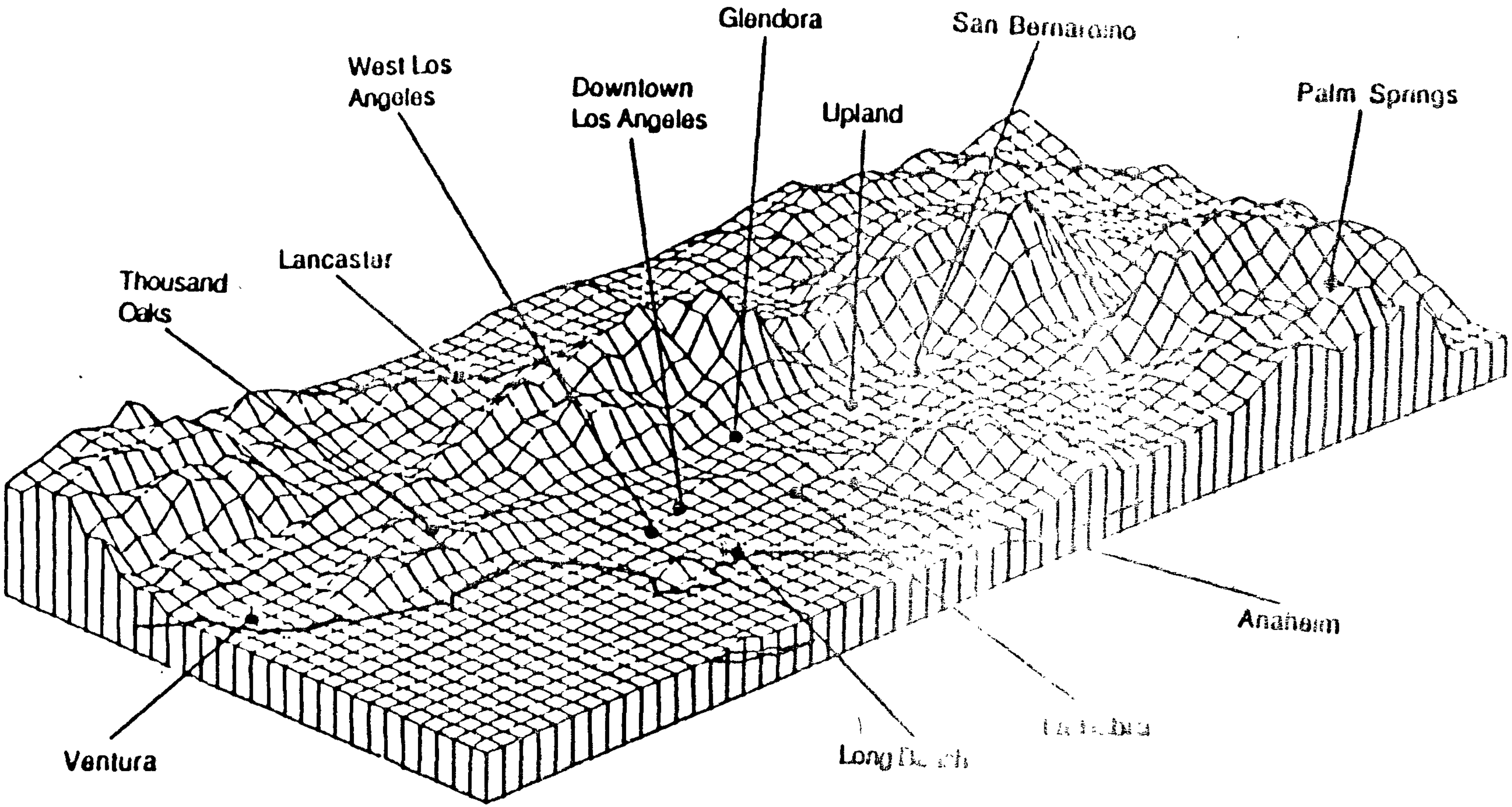


FIGURE 4-3. UAM modeling region for the California South Coast Air Basin.

90098 04''

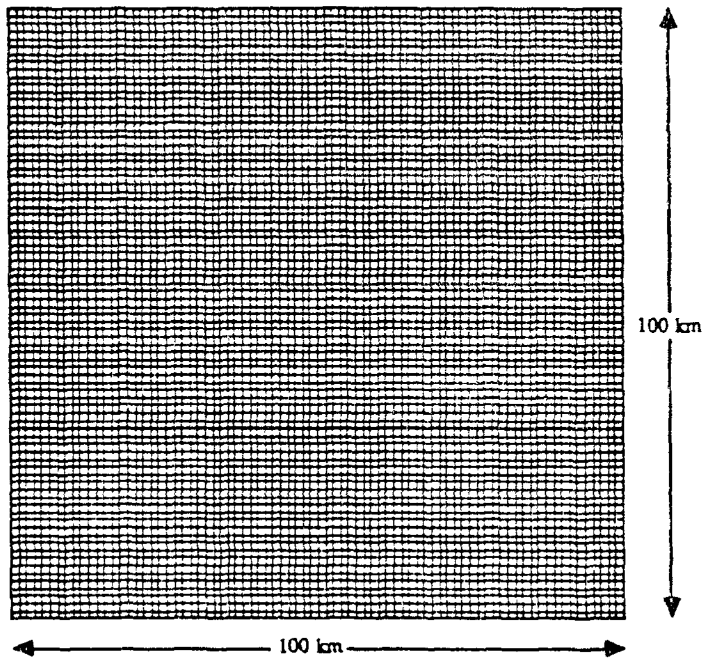
Ideally, the smallest feasible grid spacing should be chosen to accurately represent emissions from a variety of sources in different locations. The grid spacing, however, will be determined in part by the size of the modeling region.

- If the region of interest is 100 km by 100 km, a grid spacing of 2 km would result in a total of 2,500 individual cells for which emissions would have to be calculated, as shown in Figure 4-4a. For such a large area, such fine resolution is unlikely to result in appreciable improvement in predicted ozone levels over the entire region relative to a larger grid spacing, such as 5 km (Figure 4-4b). The major advantage of the larger grid spacing is the considerably fewer number of grid cells (400 as opposed to 2,500) and the corresponding reduction in both computing and manpower costs.

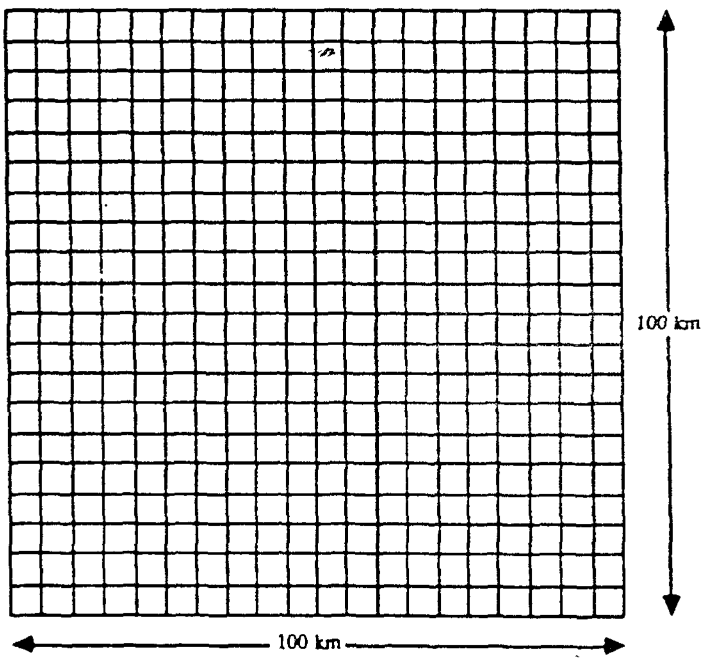
In urban-scale photochemical modeling efforts, covering the maximum amount of area with the smallest feasible number of grid cells normally results in grid spacing between 2 to 5 km. Since ozone formation occurs over an appreciable amount of time and space, grid spacing smaller than 2 km is not recommended. Also, grid spacing smaller than 2 km may exceed the resolution of both available transportation modeling data and area source apportioning factor data. On the other hand, grid spacing larger than 10 km usually masks the effect of individual sources, since emissions are averaged over the entire grid cell area by the model (i.e., when using 10 km grid spacing, all emissions in any cell, including individual point sources, are assumed to be uniformly emitted from the entire 100 square kilometer grid cell area). If the grid spacing is large, this artificial dilution can cause inaccuracies in the modeling. Users are referred to the Guideline for Regulatory Application of the Urban Airshed Model[1] for further guidance on selection of grid cell size.

If a grid system has not been chosen prior to inventory compilation, the smallest grid spacing under consideration should be used for spatial resolution of the emission inventory. Aggregation to larger grid cells is then a simple procedure of combining an integral number of grid cells. Thus, the initial emission grid spacing can be smaller than the actual grid spacing subsequently used for modeling. However, resource considerations may preclude such fine emission resolution if the inventory involves a very large grid area. Compilation of the inventory for a grid spacing larger than is subsequently considered desirable for photochemical modeling should be avoided because of the difficulty in allocating emissions to a finer grid cell network once the inventory is completed (aggregation of smaller grid cells to form larger ones, however, is relatively easy, as mentioned above). Optimally, of course, the emission grid cells will coincide in size with the grid cells used for photochemical modeling.

As an important consideration in determining the size of both the modeling region and the individual grid cells, the emissions modeler, in concert with the other agencies involved in this decision, should examine the overall objectives of the photochemical modeling application. If control strategies are to be evaluated over a large region, then a fairly large



(a) 2 km grid spacing (2,500 grid cells)



(b) 5 km grid spacing (400 grid cells)

FIGURE 4-4. Comparison of number of grid cells required for a 100 km x 100 km modeling region for 2 km and 5 km grid spacings.

modeling region should be selected and a fairly coarse emission resolution may be acceptable. If control strategies are to be evaluated for a fairly small area (e.g., an individual city, such as the St. Louis, Missouri area shown in Figure 4-2), then a relatively fine emission resolution may be warranted. Evaluating the air quality impact of a proposed new source would probably require a relatively fine emission resolution, since very large grid cells may mask the effect of the individual new source. Thus, before a final grid system is chosen, a photochemical modeling specialist should be consulted regarding the effect of emission resolution on modeling predictions.

4.2 MAP GRIDDING PROCEDURES

4.2.1 UTM Coordinate System

Once the grid system has been selected, it must be overlaid on an appropriate map to determine (1) which sources lie within each grid cell and (2) area source apportioning factors for each grid cell. The recommended coordinate system for this task is the Universal Transverse Mercator (UTM) system, which is used in the AIRS emission data system to reference all point source locations. The UTM coordinate system should be used from the outset in the development of the grid system, since changing from one coordinate system to another can be time-consuming. For those urban regions which encompass more than one UTM zone, all coordinates should be referenced to one zone.

The most accurate maps normally available for gridding purposes are those produced by the U.S. Geological Survey (USGS), which provides topographic maps in different scales for all sections of the United States. The more recent USGS maps have a superimposed 10 km UTM grid system; older USGS maps simply have blue tick marks along the edges that represent the UTM coordinate system.

The master grid system should be based on a USGS map or data base, since other maps (e.g., highway maps) may contain considerable inaccuracies. The grid system can be manually overlaid on a map by positioning a transparent plastic sheet over the map and drawing the gridded area on the plastic sheet. Alternatively, important features (such as political boundaries, streets, etc.) on the USGS map can be digitized and incorporated into a computerized data base.

4.2.2 Orientation of the Grid System

Almost without exception, the grid system should be aligned so that the grid lines essentially run north-south and east-west. Within the region typically modeled in most urban areas, a grid system based on UTM coordinates will largely meet this criterion. North-south alignment is not actually required by the photochemical model, but facilitates definition of locations on the grid and enhances compatibility of the inventory with meteorological data. For the extremely few instances where north-south alignment of the grid would cause significant modeling inaccuracies, the UAM EPS supports skewed (i.e., non-north-south) grid orientations. A photochemical modeling expert can be consulted to determine if a skewed grid orientation should be used for a particular region. Figure 4-5 shows an example of a skewed modeling region.

Likewise, for the sake of convenience, the grid should be oriented so that the grid cell boundaries coincide with the UTM kilometer grid lines (in other words, so that the grid cells are defined by whole UTM kilometer numbers). This simplifies location of particular grid cells and allocation of point sources to the appropriate grid cells. Obviously, this will not be possible if grid cell dimensions are determined in terms of non-metric units, such as miles.

4.2.3 Problems in Gridding

Often, the master grid system developed using the methods described above must incorporate features not available from USGS maps or data, such as detailed street locations, land use patterns, or population density. Other maps may not be as dimensionally accurate or on the same scale as the USGS map, which can cause major problems in combining information from different maps. While attempting to align the master grid on a land-use map, the emissions modeler may notice that certain major features are located in slightly different grid cells than on the USGS map. If the scale of the auxiliary map is not quite accurate, it may be possible to extend or decrease the map grid line dimensions so that most grid cells correspond to those on the USGS map. In many cases, the best procedure is to align the main urban area as correctly as possible. Inaccuracies in the outer portions of the grid are less important because fewer emissions normally occur in the outlying grid cells.

USGS maps, although dimensionally accurate, do not always include enough detail to locate particular sources. This is partly because of the limited number of available scales and partly because some of the available USGS maps are old and so do not show current street locations. Thus, the emissions modeler must usually obtain more detailed street maps covering the entire area of interest in order to accurately locate specific sources. If possible, all street maps should be at the same scale so that a number of them can be combined to show a larger area. Overlaying the grid system on the individual street maps can be difficult, because street maps rarely have UTM coordinates; the grid system must be carefully positioned using known reference points, such as major street intersections, shown on the USGS map. Often, the easiest way to overlay the grid system is to digitize the desired features and, using the known UTM locations of several features shown on both maps as reference points, incorporate this data into a computerized data base (such a

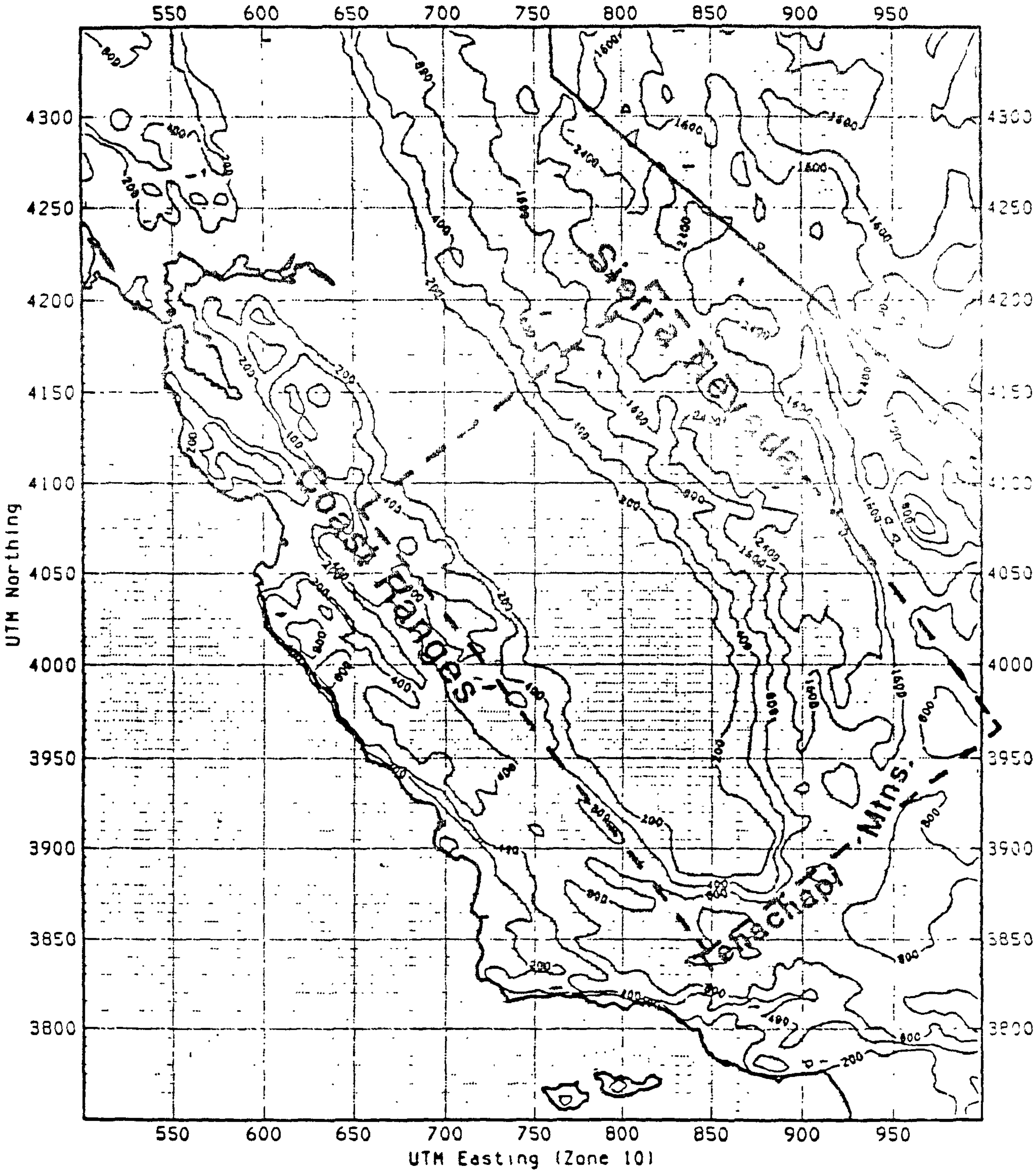


FIGURE 4-5. Modeling region encompassing the southern San Joaquin Valley and Sierra Nevada.

data base of computerized locations of streets and other features may also prove useful for apportioning emissions from some area sources).

References for Chapter 4

1. Guideline for Regulatory Application of the Urban Airshed Model, EPA-450/4-91-013, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1991.

5 POINT SOURCE EMISSIONS

5.1 DATA COLLECTION

For most urban regions, a basic annual or seasonal point source emission inventory will already exist which contains most (if not all) of the information required to develop the modeling inventory. Basic inventories are often maintained in standardized formats, such as SAMS, AIRS, or NAPAP, and generally contain the following types of information:

Source identification: county, facility, and source codes; Standard Industrial Classification (SIC) of the facility; and location (latitude and longitude or UTM coordinates) of each source.

Process information: Source Classification Code (SCC) or basic equipment codes for each process; stack parameters (height, diameter, gas temperature, and gas exit velocity or flowrate); control device information; operating rates and schedules; and fuel characteristics.

Emissions data: annual or seasonal estimates of VOC, NO_x, and CO emissions for each process within the facility.

Table 5-1 lists the types of data contained in the Aerometric Information Retrieval System (AIRS) Facility Subsystem (AFS) and the level at which each is maintained. Table 5-2 lists the data items currently required by the UAM EPS for processing of the point source inventory. The existing point source inventory will generally fulfill most of the photochemical modeling requirements; one notable exception may be the lack of sufficient operating schedule information to accurately estimate hourly emission rates. Additionally, VOC and NO_x emissions will need to be disaggregated into chemical classes and NO and NO_2, respectively. Techniques for speciation of VOC and NO_x emissions are discussed separately in Chapter 9.

The UAM EPS program PREPNT expects point source information (such as stack parameters and emissions estimates) to be reported in the units of measure indicated in Table 5-2. PREPNT contains routines which convert this data to the units expected by subsequent programs in the UAM EPS. If the units used in the existing point source inventory differ from those in Table 5-2, the emissions modeler will have to either develop an auxiliary preprocessing

TABLE 5-1. Types of emissions data contained in the AIRS Facility Subsystem and the level of detail at which each is maintained.

LEVEL	TYPES OF DATA
Plant (data pertaining to the facility as a whole)	geographic and other address information year of emission inventory estimated plant pollution emissions comment information about the facility miscellaneous mailing label and permit fee data
Stack (data pertaining to emissions stacks or vents within the facility)	map coordinates and physical description gas flow rate, exit velocity and temperature estimated and measured emissions by pollutant stack comment data
Point (data pertaining to emissions points within the plant, frequently boilers or tanks)	point design capacity burner make, type and seasonal throughput data operating schedule estimated, measured and state defined pollutant emissions values tank descriptive and construction data comment information about the emission point
Segment (data pertaining to activities or components, such as fuel combustion and other processes, associated with each point)	segment source classification code (SCC) operating rate, fuel, control equipment and emission factor data estimated and measured emissions by pollutant segment chemical data comment information pertaining to the segment

source: Reference 2

TABLE 5-2. Data fields required by the UAM Emissions Preprocessor System.

Variable	Description
STATE	NEDS state code
COUNTY	NEDS county code
PLANT_ID	Plant ID code
UTM_ZONE	UTM zone
POINT_ID	Point ID code
SIC	Standard Industrial Classification code
LAT	Latitude, degrees
LON	Longitude, degrees
WINTHRU	Winter throughput, %
SPRTHRU	Spring throughput, %
SUMTHRU	Summer throughput, %
FALTHRU	Fall throughput, %
HOURS	Hours/day in operation
DAYS	Days/week in operation
WEEKS	Weeks/year in operation
STACK_HT	Stack height, ft
STACK_DI	Stack diameter, ft
STACK_TP	Stack temperature, °F
FLOW	Gas flow rate, cubic ft/min
PTSCONST	Range of points with common stack, AAZZ
SCC	Source Classification Code
NOXEMISS	NOx emissions, tons/yr
TSPEMISS	TSP emissions, tons/yr
COEMISS	CO emissions, tons/yr
SOXEMISS	SOx emissions, tons/yr
THCEMISS	THC emissions, tons/yr

source: Reference 1

program to reformat the existing inventory to be compatible with PREPNT or modify the PREPNT source code to bypass the conversion calculations.

In general, the point source data collection methodologies described in Procedures for the Preparation of Emission Inventories for Precursors of Ozone, Volume I[3] can also be used to collect any additional data required for the modeling inventory. In short, these procedures include mail surveys of individual facilities, use of other air pollution agency files (such as permit applications), use of information from selected publications, and examination of other available inventories. The emissions modeler should consult Volume I for a detailed discussion of these techniques. The remaining sections of this chapter focus on the additional data requirements of the modeling inventory and specific data handling techniques.

5.2 RULE EFFECTIVENESS

Although past inventories have assumed that regulatory programs would be implemented with full effectiveness, experience indicates that regulatory programs are less than 100 percent effective for most source categories in most areas of the country. Accordingly, a "rule-effectiveness" factor should be applied (in addition to the control factors associated with each measure) to account for less than full compliance.

When estimating the effectiveness of a regulatory program, several factors should be considered. These include:

- the nature of the regulation (e.g., whether any ambiguities or deficiencies exist, and whether test methods and/or recordkeeping requirements are prescribed);

- the nature of the compliance procedures (e.g., accounting for the long-term performance capabilities of the control);

- the performance of the source in maintaining compliance over time (e.g., training programs, maintenance schedules, and recordkeeping practices); and

- the performance of the implementing agency in assuring compliance (e.g., training programs, inspection schedules, and follow-up procedures).

The current ozone/carbon monoxide policy states that a factor of 80 percent can be used to estimate rule effectiveness in base year inventories. Alternatively, states are given the option of deriving local category-specific rule effectiveness factors (within tightly prescribed guidelines) as EPA deems appropriate.

Rule effectiveness should be incorporated into all baseline and projected inventories with the following exceptions: (1) sources not subject to the regulation; (2) sources achieving compliance by means of an irreversible process change that completely eliminates solvent use; and (3) sources for which emissions are directly determined by calculating solvent use over some time period and assuming that all solvent was emitted from the source during that time period. The rule effectiveness factor is applied to the estimated control efficiency as shown in the following example.

- If uncontrolled emissions from a given source are 50 lbs/day, and the estimated control efficiency of a proposed measure is 90%, the actual controlled emissions accounting for a rule effectiveness factor of 80% are calculated to be [50 lbs/day] x [1 - (0.90) x (0.80)], or 14 lbs/day. The total emissions reduction is thus 72 percent.

5.3 SPATIAL RESOLUTION

Since photochemical models require that all emissions be associated with specific grid cells, the emissions from each point source must be assigned to the grid cell in which the point is located. This assignment can either be performed manually (using maps) or with the assistance of a computer.

Point sources can be manually assigned to grids by locating their coordinates (UTM or latitude and longitude) or street addresses on a map of the area which is overlaid with the inventory grid system, as described in Section 4.2.1. As a basic quality assurance procedure, street addresses should be checked against the coordinates included in the basic inventory to identify possible errors in coordinate assignments. Usually, each grid cell is assigned a number according to some model-specific system, and this grid number and the source-type category should be entered into the data handling system for each point source to facilitate subsequent processing.

Alternatively, a computer program can be used to assign grid cell coordinates to each source based on the location data contained in the annual or seasonal point source inventory. This approach, which is generally more efficient than manual location of point sources on a map, is especially attractive if the grid assignment process may have to be repeated numerous times, as would be the case if the grid orientation or grid cell size were to change. However, even if the grid assignment is computerized, the emissions modeler may find it useful to overlay the grid system over an accurate map of the area to assist in visualizing and checking grid cell assignments, especially for the largest emitters in the region.

In the UAM EPS, grid cells are identified by the (I,J) coordinate of the upper right corner of each cell; for example, the grid cell at the origin of the grid system is identified by the (I,J) cell coordinates (1,1). The PREPNT program converts latitudinal and longitudinal coordinates to UTM coordinates and assigns emissions from each point source to the appropriate grid cell.

If the existing point source inventory locates point sources using UTM coordinates instead of latitude and longitude, a minor modification to the PREPNT source code will bypass the conversion from latitude and longitude to UTMs, as mentioned in Section 5.1.

5.4 TEMPORAL RESOLUTION

The modeling inventory should represent day-specific emission estimates for each hour of the modeling episode. By contrast, the existing point source inventory will more likely contain annual or typical ozone season day estimates of emissions and a general description of the operating schedule (seasonal fractions of annual throughput, and operating schedule in terms of weeks/year, days/week, and hours/day in operation). This information may need to be augmented for the modeling inventory. Several approaches for this augmentation are available, including contacting the plant or local agencies, extrapolating from the information contained in the existing inventory, and using engineering judgement to develop typical temporal profiles for the source types in question.

Ideally, each facility would be contacted to obtain hourly operating records for the modeling episode, or, if this information is unavailable, representative operating schedules for a typical ozone season day. Certain local agencies may also have this type of temporal information. Resource limitations, however, generally make determination of source- or episode-specific operating schedules impractical except for the largest emitters in the area. Some sources for which this type of data may be available include the following: power plants (which generally keep detailed, hourly records of fuel firing rates and power output for each day of operation), major industrial facilities such as automotive assembly plants and refineries, and tank farms.

The UAM EPS supports incorporation of episode-specific hourly emissions estimates for individual point sources into the modeling inventory. Table 5-3 shows the day-specific Model Emission Record Format (MERF) supported by the UAM EPS, which allows the user to specify the hourly fractions used to

TABLE 5-3. Day-specific Modeling Emissions Record Format (MERF) used by the UAM Emissions Preprocessor System.

Variable	Columns	Type	Description
ISRG	1-3	I	Gridded surrogate code (not used, skipped)
IFIP	4-8	I	FIPS state/county code (not used, skipped)
SIC	9-12	R	Either Source Industrial Classification or Area Source Category code
SCC	13-20	A	Either Standard Classification Code or Area Source Category code
ICL	21-23	I	I coordinate of grid cell
JCL	24-26	I	J coordinate of grid cell
IYR	27-28	I	Year, two digits (e.g., 89 for 1989)
IDYCOD	29-30	I	Diurnal variation code[1]
IWKCOD	31-32	I	Weekday variation code[2]
FID	33-41	A	Facility ID (0 or blank for area sources)
FST	42-46	A	Stack ID (0 or blank for area sources)
FCNTY	47-52 53-56	I -	AEROS state/county code (Not used, skipped)
VMNTH	57-116	R	Array of 12 hourly factors[3]
CO	117-126	R	CO episode emissions (annual average kg/day)
CNO	127-136	R	NO_X episode emissions (annual average kg/day)
SOX	137-146	R	SO_X episode emissions (annual average kg/day)
THC	147-156	R	THC episode emissions (annual average kg/day)
PM	157-166 167-168	R -	PM episode emissions (annual average kg/day) (Not used, skipped)
SLBL	169-175	A	Scenario label (not used, skipped)

[1] Either -1 or -2, corresponding to the first 12 hours of the day or the second 12 hours of the day, respectively.
[2] Always equal to 0 in day-specific MERF.
[3] Factors used to allocate daily emissions to hours of day; correspond to first 12 hours of day if IDYCOD = -1 and second 12 hours of day if IDYCOD = -2.

source: Reference 7

diurnally allocate total daily emissions (note the differences between the day-specific MERF and the standard MERF shown in Table 3-1).

The currently available version of the UAM EPS (Version 1.0) does not provide software to generate day-specific MERF records; accordingly, this information must be incorporated into the modeling inventory outside of EPS using supplemental software or by manual editing of the point source MERF file produced by PREPNT.

For many smaller point sources, reasonable temporal resolution can be obtained from the operating data that are typically coded on each basic point source record.

- Consider an operation with annual emissions of 20 tons of VOC, with 40 percent of annual throughput occurring in the summer. This source normally operates 12 hours per day and seven days each week. Assuming uniform hourly emissions over a 13-week summer, the emissions rate is estimated to be (20 x 0.4)/(12 x 7 x 13) or 0.0073 tons per hour. Applying the conversion factor, 907 kg/ton, gives 6.7 kg/hr as the average emissions during summer operations. In the absence of more specific data, these emissions might be assigned to the period 0700 to 1900 each day.

The UAM EPS can perform these temporal adjustments automatically based on the operating data contained in the basic inventory. The PREPNT program converts seasonal fractions of throughput to a monthly variation profile (assuming uniform variation throughout the season) and assigns default day-of-week and diurnal activity profiles based on the number of days per week and the number of hours per day in operation. (The default profile assignments contained in the PREPNT source code should be reviewed for compatibility with typical operating patterns for the region.)

The PREPNT program automatically applies one temporal adjustment (which the user should be aware of) based on the number of weeks per year in operation for each source. For example, if a particular source having VOC emissions of 100 tons/year is only in operation 45 weeks out of the year, the actual VOC emission rate for those days on which the source is in operation will be [(100 tons/year)]/[45 weeks in operation/52 weeks in a year)]/[365 days per year], or 0.32 tons/day, as compared to an average daily rate of 0.27 tons/day (100/365) which would occur if the source were in operation for the entire year. To ensure that the more conservative estimate of daily emissions is incorporated into the modeling inventory (where "conservative" is defined as possible overestimation rather than underestimation of emissions), the PREPNT program assumes that any source not operating for the entire year will be in operation during the modeling episode. This assumption, of course, will have no effect for those sources which indicate no activity during the season (or month) to be modeled.

Note that if seasonal rather than annual emission estimates are available, the emissions modeler should take care that redundant seasonal adjustments are not applied. This is readily accomplished by preprocessing the existing point source inventory, setting all seasonal fractions to 25% and the number of weeks in operation per year to 52 to ensure that the EPS does not further adjust emissions which are already on a seasonal basis.

For many sources, daily operation will be confined to one or two workshifts; thus, hourly operation during working hours would be determined by dividing the daily operating rate by 8 or 16. If hourly operating information is contained in local agency files, it may supersede the less detailed information contained in the basic point source inventory.

Often, no operating data will be coded in the existing point source inventory for some sources. For those sources which are too minor to warrant directly contacting the facility, engineering judgement can often provide satisfactory estimates of hourly emissions.

- Many commercial establishments will operate all year, but only be open 8 to 10 hours a day and 5 to 6 days a week. Hence, as a good approximation, the annual operating rate in the basic point source record for these sources can be divided by 2,080 (i.e., 52 x 5 x 8) to estimate an hourly operating rate applicable during working hours.

The UAM EPS assigns a flat operating profile (i.e., equal seasonal fractions of annual throughput, and 52 weeks/year, 7 days/week, and 24 hours/day) to each source in the inventory with missing temporal variation data. A flat operating profile is also assigned to those sources with "suspect" or invalid operating data (e.g., if a source reported an operating schedule of 8 days/week).

Above-ground fixed-roof petroleum product storage tanks present a unique situation that should be handled outside of EPS because breathing loss emissions appear to be a function of time of day rather than operation.[4] These tanks begin expelling vapors when heated by sunshine in the morning, and cease expelling vapors in the mid-afternoon when the heating process ceases. As an approximation, breathing loss emissions from fixed roof storage tanks can be assumed to occur uniformly from 8:00 a.m. to 3:00 p.m. (this information can easily be incorporated into the modeling inventory using the day-specific MERF shown in Table 5-3). Daily emissions from storage tanks can be estimated using procedures given in AP-42, Compilation of Air Pollutant Emission Factors.[5]

Tables 5-4 and 5-5 show the default weekly and diurnal activity profile codes provided with the UAM EPS. The values in these tables represent relative levels of activity by hour of day and day of week, respectively. These temporal variation codes are assigned in PREPNT (for point sources) and GRDEMS (for area and mobile sources). The weekly profiles listed in Table 5-4 are used in conjunction with monthly activity fractions to compute representative episodic emissions levels from the annual (or ozone-season) average emissions contained in the existing inventory; this calculation is similar to that described previously for adjusting emissions based on number of weeks per year in operation and can be mathematically represented as

$$E_{ED} = (E_{AA}) \cdot (M_F \cdot 12 \text{ months/yr}) \cdot [(7 \text{ days/wk total}) / D_F] \quad (5\text{-}1)$$

where E_{ED} denotes episodic daily emissions, E_{AA} denotes annual average daily emissions, M_F is the fraction of annual activity occurring in the episode month, and D_F is a day of week adjustment factor obtained by dividing the value in Table 5-4 for the day of week of the episode by the total for the day.

For example, if the weekly variation in activity for a particular point source having annual average emissions of 10 tons/day of VOC and no seasonal variation is be characterized by profile code 22, representative daily emissions for a Tuesday are calculated to be (10 tons/day VOC) x (0.083 x 12) x (7 / (10 / 61)), or 11.5 tons/day VOC. Diurnal variations in emissions are accounted for by multiplying the episodic daily emissions calculated above by the fraction of total daily activity occurring in a given hour; if the diurnal variation for the point source described above was characterized by profile code 35 from Table 5-5, the fraction of episodic daily emissions occurring in the hour between 7 and 8 a.m. would be (8 / 182), or 9.8 percent (corresponding to 1.1 tons VOC).

If none of the existing profiles listed in Tables 5-4 and 5-5 match the typical temporal variations for a given source or type of source, additional profiles can be created and added to the appropriate files. Alternatively, existing profile codes can be redefined to reflect the desired temporal distributions. Appendix B provides additional guidance on creation of new diurnal and weekday profile codes and redefinition of existing codes.

TABLE 5-4. Default weekday variation codes used in the Emissions Preprocessor System

Code	Relative Emissions Contribution by Day of Week							Total
	MON	TUE	WED	THU	FRI	SAT	SUN	
1	1	1	1	1	1	0	0	5
2	0	0	0	0	0	1	1	2
3	1	1	1	1	1	0	0	5
4	1	1	1	1	1	0	0	5
5	1	1	1	1	1	0	0	5
6	1	1	1	1	1	1	0	6
7	1	1	1	1	1	1	1	7
21	1	1	1	1	1	2	2	9
22	10	10	10	10	10	7	4	61
23	5	5	5	5	5	4	4	33

source: Reference 7

TABLE 5-5. Default diurnal variation codes used in the Emissions Preprocessor System.

Diurnal Profile Code	Emissions Contribution by Hour (0 to 23)																								Total Daily Activity
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
3	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
4	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
5	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
6	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
7	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
8	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
9	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
10	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
11	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
12	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
13	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	16
14	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
15	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
16	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
17	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
18	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
19	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
31	3	1	1	1	1	1	1	5	5	5	5	5	5	5	5	5	5	10	10	10	10	7	7	3	116
33	2	2	2	2	2	2	2	10	10	6	6	5	5	5	5	5	5	6	1	10	10	10	10	2	128
34	0	8	8	8	8	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72

continued

90098 05'

TABLE 5-5. Concluded.

Diurnal Profile Code	Emissions Contribution by Hour (0 to 23)																							Total Daily Activity
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
35	10	1	1	1	1	1	1	8	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	182
37	0	0	0	0	0	1	3	6	9	10	10	10	10	10	10	10	10	9	6	3	1	0	0	0	118
38	0	0	0	0	0	2	6	6	2	2	1	2	4	4	2	1	1	3	10	8	7	6	1	0	68
40	0	0	0	0	2	3	4	4	4	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	41
41	0	0	0	0	0	0	18	59	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	37	35	0	0	0	0	0	0	100
43	14	11	3	2	4	19	27	0	50	78	88	94	99	93	99	3	3	3	98	70	60	44	33	14	999
44	8	8	2	1	1	4	12	36	48	54	70	72	71	68	75	76	84	78	65	56	42	35	25	8	999
48	9	1	1	1	1	7	9	32	43	61	97	84	89	80	78	77	89	72	44	42	41	20	20	8	996
50	1	1	1	1	1	1	6	10	6	5	5	5	5	5	5	6	10	8	6	4	1	1	1	1	96
56	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
51	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	6
52	0	0	0	0	0	1	6	10	10	10	10	10	6	3	3	3	4	4	0	0	0	0	0	0	83
53	0	0	0	0	0	0	0	2	2	2	2	2	0	1	0	0	0	0	0	0	0	0	0	0	11
55	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	22
57	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	21
58	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	19
59	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	11	1	1	0	20
60	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	12
61	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
62	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	10
63	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	11
64	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
65	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	9
66	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	13
67	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	14
68	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	15
69	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	7

source: Reference 7

concluded

90098 05''

5.5 POINT SOURCE PROJECTIONS

As discussed in Chapter 2, emission projections must account for anticipated growth in activity levels as well as the effects of any regulations under consideration to control ozone precursor or CO emissions (be sure to also account for rule effectiveness in emission projections, as discussed in Section 5.2). The baseline projection inventory should accordingly include the effects of expected growth in future years and the reduction in emissions that should occur as a result of existing control regulations. Control strategy projections, on the other hand, must also consider the reductions in emissions that would occur if alternative or additional regulatory programs were adopted. Control strategy projections may also take into account other-than-expected growth patterns which might result from the alternate control programs. This section presents various methods for projecting point source emissions; the emissions modeler, however, should consult the EPA guidance document concerning emission inventory projection techniques (to be released in July, 1991) for definitive guidance on projection of point source emissions.

5.5.1 Individual Facility Projections

The most rigorous approach for projecting emissions from major point sources is to obtain information on each facility. Ideally, this type of information would be determined by contacting plant management directly or could be solicited on questionnaires. Generally, questionnaires would not be sent out solely to solicit projection information; however, this additional information may be solicited on questionnaires used to periodically update the baseline inventory. Permit applications submitted to various Federal, State, and local agencies should also be screened to get information on expected expansion or new construction. The local Metropolitan Planning Organization (MPO) and other planning bodies should also be contacted for any information they may have on projected industrial expansion as well as to comment on the reasonableness of any plans submitted by plant personnel.

Once the agency responsible for the modeling inventory obtains this type of projected plant growth information, it needs to determine what regulations will apply, in order to estimate controlled emissions. Appendix C of Volume I[3] summarizes the EPA Control Technique Guideline (CTG) documents. The baseline projection should incorporate any existing applicable regulations.

- A fossil-fueled power plant now under construction and expected to start operation in 2 years would be subject to Federal new source performance standards for particulates, SO_2, and NO_x. Hence, it would be reasonable to assume emission levels equal to the standards unless plant personnel indicate more stringent controls will be applied for some reason (e.g., to meet a more stringent local standard). Similarly, in control strategy projections, effects of any alternative standards would have to be evaluated.

When obtaining projection information from plant management, it is important to inquire whether projected increases in activity will occur at the existing facility or elsewhere (i.e., at another existing plant or at a new plant). If occurring at an existing facility, the emissions modeler also needs to determine whether the growth will be expansion to existing capacity or will require additional capacity. These considerations are especially important for major sources, since emissions must be assigned to a specific grid cell. This information will also help to determine what additional control measures are likely to be required. The schedule for completion of any expansion or new construction is also needed, in order to determine in what year the source must be included in the projection inventory.

- Consider a facility employing a large open-top vapor degreasing operation that emitted 100 tons of solvent per year in 1987 (based on an annual production of 10,000 of a certain kind of metal part.) Assume that no control measures were taken to reduce solvent losses from the process. Now, suppose plant contacts indicate that 5 percent more metal parts would be produced per year until 1992 using the existing operation. Then, in order to estimate VOC emissions from this source for a 1992 projection inventory, one could assume that since no additional controls would be expected, the current emission level could be multiplied by the ratio of cumulative growth in metal parts production (i.e., 5 years at 5 percent/year = $[1.05]^5$ = 1.28, or 128 percent) to estimate VOC emissions in 1992. In this manner, emissions in 1992 would be estimated at 128 percent of 100, or 128 tons per year, and the point source record for this projection year should be adjusted accordingly to take this growth into account.

As is obvious from this example, even when projection information is available for specific facilities, certain assumptions will have to be made in order to project emission levels for some future year. For instance, in the 1992 baseline projection, it was assumed that emissions would increase proportionately with production. Depending on the nature of the operation, this may not necessarily be entirely accurate. This underscores the point made in Section 2.4 that projections are always somewhat speculative in nature.

5.5.2 Aggregate Point Source Projections

In many instances, projection information will not be available for every facility in an area of interest. Some facility managements will not be willing or able to provide forecasts of their corporate plans, especially for more distant years. In addition, many plants in certain source categories (e.g., small industrial boilers) will be too small and too numerous to warrant the solicitation of projection information individually. In these situations, other procedures need to be employed to make projections of future emissions. Two possible approaches are discussed below; in all cases, however, the emissions modeler should consult current EPA guidance for inventory projection to determine the most up-to-date databases and applicable parameters for aggregate projection of future-year inventories.

In one case, projection information may be available on many point sources within a given category, but for various reasons is not obtainable for one or several facilities. In this situation, a reasonable approach to projecting growth and emissions at the remaining facilities would be to evaluate the growth trends in the facilities for which projections are known and apply them to the facilities for which no information was available.

- Suppose there are 10 paint manufacturing facilities in the area of interest, and successful contacts may have been made with only eight of these. If production was expected to expand by 6 percent per year, on average, for the eight plants, then this rate could be applied to the remaining two plants to estimate expected growth. Then, knowing the increase in production, the appropriate control measures would be taken into consideration in making a baseline projection. In some cases, the emissions could be directly estimated by applying the average growth rate to a base year emission for each facility.

Good engineering judgment is needed in this practice to screen out any unreasonable projections that may result.

For minor point sources, such as cold cleaning operations, where individual solicitation of projection information is unwarranted, the rate of growth of activity may be assumed equivalent to that of some growth indicator category for which projections have been made. Sources of growth indicator projections include local MPO's and the U.S. Department of Commerce's Bureau of Economic Analysis (BEA).[6] For example, it might be assumed that cold cleaning operations would grow at the same rate as industrial manufacturing in general. This rate can be readily estimated from projections of employment in industrial manufacturing categories. Table 5-6 lists the categories for which the BEA makes projections at the state and Metropolitan Statistical Area (MSA) level, along with the two-digit SIC designations associated with each category (in addition to the state- and MSA-level projections, BEA also publishes projections for BEA Economic Areas, which are larger than MSAs). Note that MSA-level projections are not available for most two-digit SIC designations. Table 5-7 shows an example of these projections for the state of California. The BEA projections of industrial employment are regularly updated and may be used, in the absence of local projections, as general indicators of growth.

In the UAM EPS, projected growth factors are applied by two-digit SIC designation. These growth factors are expressed as ratios of future year to

TABLE 5-6. Industrial groupings for BEA economic projections.

Industries projected for MSAs	Industries projected for States and the Nation	1972 SIC code[1]
Farm	**Farm**	01, 02
Agricultural services, forestry, fisheries, and other	**Agricultural services, forestry, fisheries, and other**	07, 08, 09
	Agricultural services, forestry, and fisheries	. ...
	Other[2]	
Mining	**Mining**	
	Coal mining	11, 12
	Oil and gas extraction	13
	Metal mining	10
	Nonmetallic minerals, except fuels	14
Construction	**Construction**	15, 16, 17
Manufacturing	**Manufacturing**	
Nondurable goods	Nondurable goods	
	Food and kindred products	20
	Tobacco manufacturers	21
	Textile mill products	22
	Apparel and other finished textile products	23
	Paper and allied products	26
	Printing and publishing	27
	Chemicals and allied products	28
	Petroleum and coal products	29
	Rubber and miscellaneous plastic products	30
	Leather and leather products	31
	Durable goods	
	Lumber and wood products, except furniture and fixtures	24
	Furniture and fixtures	25
	Stone, clay, and glass products	32
	Primary metal industries	33
	Fabricated metal products	34
	Machinery, except electrical	35
	Electric and electronic equipment	36
	Transportation equipment, except motor vehicles	37 except 371
	Motor vehicles and equipment	371
	Ordnance[3]	....
	Instruments and related products	38
	Miscellaneous manufacturing	39
Transportation and public utilities	**Transportation and public utilities**	
	Railroad transportation	40
	Trucking and warehousing	42
	Local, suburban, and highway passenger transportation	41
	Air transportation	45
	Pipeline transportation	46
	Transportation services	47
	Water transportation	44
	Communication	48
	Electric, gas and sanitary services	49

continued

TABLE 5-6. Concluded.

Industries projected for MSAs	Industries projected for States and the Nation	1972 SIC code[1]
Wholesale trade	**Wholesale trade**	50, 51
Retail trade	**Retail trade**	52-59
Finance, insurance, and real estate	**Finance, insurance, and real estate**	
	Banking	60
	Other credit and securities agencies	61, 62 67
	Insurance	64, 64
	Real estate and combination offices	65 66
Services	*Services*	
	Hotels and other lodging places	70
	Personal, business, and miscellaneous repair services	72, 73, 76
	Automotive repair services and garages	75
	Amusement and recreation services	79
	Motion pictures	78
	Private households	88
	Health services	80
	Private educational services	82
	Nonprofit organizations	83, 84, 86
	Miscellaneous professional services	81, 89
Government and government enterprises	Government and government enterprises	
Federal, civilian	*Federal, civilian*	
Federal, military	Federal, military	
State and local	State and local	

[1] Historical data through 1974 are classified according to the 1967 SIC definitions; subsequent historical data and projections are classified according to the 1972 SIC definitions.

[2] Refers to United States residents employed by international organizations.

[3] *The ordnance classification was discontinued in the 1972 SIC definitions. Earnings and employment previously included in ordnance are now* included in one or more of the following classes: fabricated metal products (SIC 34); electric and electronic equipment (SIC 36); transportation equipment, except motor vehicles (SIC 37, except 371); and instruments and related products (SIC 38).

source: Reference 6 concluded

Note that projections at the MSA level are only available for broad industrial classifications which include numerous two-digit SIC designations (e.g., the MSA-level projections for Mining include aggregated estimates for SICs 10, 11, 12, 13, and 14); by contrast, separate projections are provided for these subcategorizations at the state and national levels.

TABLE 5-7. Employment by place of work (thousands of jobs), historical years 1973-1988 and projected years 1995-2040, for California (excerpt).

	1973	1979	1983	1988	1995	2000	2005	2010	2020	2040
Manufacturing	1686.5	2067.9	2012.8	2237.4	2332.8	2394.6	2424.9	2435.0	2352.7	2222.6
Nondurable goods	557.7	667.7	651.6	741.6	793.5	826.7	842.3	848.0	821.7	778.7
Food and kindred products	170.8	190.7	179.9	179.4	182.3	183.8	182.1	179.3	168.6	153.2
Chemicals and allied products	55.6	65.6	64.3	76.3	79.0	80.8	81.5	81.3	77.9	72.6
Petroleum and coal products	24.5	26.7	30.9	28.1	27.9	28.0	27.6	27.1	25.4	22.9
Rubber and miscellaneous plastic products	52.5	69.5	62.4	73.9	81.7	86.6	89.8	91.6	90.5	88.0
Durable goods	1128.8	1400.2	1361.1	1495.8	1539.3	1568.0	1582.5	1587.1	1531.1	1443.9
Primary metal industries . .	59.7	59.8	43.4	44.0	43.1	43.0	42.5	41.7	39.1	35.2
Electric and electronic equipment	261.3	321.8	368.0	396.8	397.1	397.5	398.0	398.3	383.0	359.6
Motor vehicles and equipment	42.2	29.9	30.4	35.6	33.8	32.6	31.5	30.6	28.2	25.0
Stone, clay, and glass products	57.1	62.8	54.1	63.8	66.9	68.5	69.7	70.7	69.1	66.4
Transportation and public utilities . . .	499.6	579.5	589.5	662.2	736.0	779.8	807.5	825.2	818.6	797.2
Railroad transportation	38.1	32.8	24.8	18.6	15.3	13.9	12.8	12.1	10.7	8.8
Local and interurban passenger transit	24.7	29.2	28.5	36.8	41.4	44.3	45.9	46.8	46.1	44.8
Electric, gas, and sanitary services	67.7	70.5	76.3	89.3	98.4	105.3	109.3	111.7	110.5	107.7
Wholesale trade	473.4	606.4	636.0	777.1	868.0	920.0	950.9	992.3	995.4	989.0
Retail trade	1504.8	1957.8	2064.7	2486.7	2833.0	3071.6	3234.4	3331.3	3330.0	3293.1

source: Reference 6

base year activity levels indicators (e.g., number of employees); accordingly, a separate set of growth factors will be required for each projection year.

Regardless of the indicators used for projections, the basic mechanics of projecting the emission inventory are the same: the ratio of the value of the surrogate indicator in the projection year to its value in the base year is multiplied by the aggregated activity level for the point source category in the base year.

- For example, if pharmaceutical manufacturing operations in the San Francisco Bay Area are assumed to correlate with the chemicals and allied products manufacturing sector in Table 5-7, then the level of this activity in 1995 would be 79.0/76.3, or 1.04 times that in 1988.

In many cases the projection years of interest to the air pollution control agency will not directly correspond to the years for which growth projections have been made, thus requiring interpolation of the growth indicators. Consult local authorities to determine if straight-line or some other interpolation method should be employed.

Once aggregate growth has been determined for a source category in the above manner, the increased activity must be allocated appropriately to the grid cell level. Often, difficult assumptions must be made regarding the probable location of the new activity. One way to apportion growth is to assume that it occurs only at existing facilities in the same source category.

- If the 10 paint manufacturing facilities in the previous example manufactured 10 million gallons of paint in 1987, and 15 million gallons were projected in 1992, then the additional 5 million gallons could be assumed to be manufactured at these same facilities. The amount of production assigned to each facility would be proportional to the quantity currently manufactured there.

If it seems unreasonable to assume that all growth within a particular source category will occur at existing facilities, an alternative is to apportion the growth according to the fraction of increase of industrially zoned land within each grid.

- Using the above example again, if 5 percent of the projected area-wide increase in industrially zoned land occurred within a given grid cell, then 250,000 gallons per year (or 5 percent of 5 million gallons) of additional paint production would be assigned to that cell.

In this approach, since the growth is not assigned to existing facilities, hypothetical point source records will have to be created and added to the inventory. Note that all information contained in a point source record (including process identification codes and stack parameters) will need to be estimated for each hypothetical point source. Again, existing applicable control regulations must be evaluated in order to determine the baseline projected emissions.

5.5.3 Control Strategy Projections

A control strategy projection is an estimate of emissions for some future year which considers the effect of proposed control measures. Control strategy projections should be made for the same years as the baseline projections to facilitate comparison of the relative effects of each strategy as well as to determine which strategy provides the necessary control of ozone precursor emissions.

In order to evaluate the relative merits of various control measures, the agency will often need to develop several different control strategy inventories for each of the projection years. Basically, a control strategy projection is generated by applying anticipated control factors to the baseline projected emissions from sources affected by the proposed measures. Obviously, the first step in this process is to identify all affected sources for each measure under consideration. Then, the anticipated emissions reduction associated with each measure (usually expressed as a percent reduction) is applied on a source-by-source basis. This procedure is not particularly difficult, but the large number of calculations required (particularly if several control strategies are under consideration) can generally be performed more efficiently with the aid of a computer.

> The UAM EPS program CENTEMS applies user-specified reduction factors by control category designation. For each control code, a separate control factor must be supplied for each of the pollutants included in the Modeling Emission Record Format (THC, NO_x, CO, SO_x, and PM). The control categories as they are currently defined are listed in Table A-3 of Appendix A. Each unique SIC/SCC pairing is assigned a specific control code in the category glossary input file to the CENTEMS program; the user should review this file to ensure that all applicable SIC/SCC pairings are included.

5.5.4 Point Source Projection Review and Documentation

Because the projection inventories are so important to control strategy development and evaluation, they should be reviewed internally by the air pollution control agency and presented to as many other groups as possible for comment before being finalized. All assumptions, procedures, and data sources must be carefully documented. Thorough review and documentation helps ensure that the projections are (1) consistent with other projections being made by various groups in the area, (2) objective in the sense that they are not biased in order to promote a particular policy, (3) open, because all assumptions, etc., are clearly stated for public review, and (4) defensible, because of all the above characteristics.

Three key aspects of point-source projections will invite criticism:

(1) the choice of indicators for projecting activity level growth;

(2) when and where this growth will occur, and concomitantly, whether it will be accommodated by expansion of existing facilities or new construction; and

(3) what emissions will be associated with this growth, either in the baseline case or as a result of various candidate control strategies.

When planning, compiling, and reviewing the point source projection inventory, the agency should focus particular attention on these issues.

5.6 DATA HANDLING CONSIDERATIONS

As mentioned in Section 5.3, either a manual or computerized approach can be utilized to assign point source emissions to specific grid cells. Generally, unless there are very few point sources in the modeling area, a computerized assignment proves more practical. In this approach, a computer program compares the UTM (or other) coordinates stored in each point source record with the coordinates of the grid cells and determines in which specific grid cell the point is located. The appropriate grid cell identifier (or coordinates) can either be stored in the point source record (if space is available) or in a separate correspondence file. Subsequently, any time a model-compatible inventory is generated, this point-to-grid-cell correspondence information can be accessed to assign point source emissions to grid cells.

In the Model Emissions Record Format employed by the UAM EPS (Table 3-1), the point-to-grid-cell correspondence is stored in the emissions record for each point source. The program PREPNT makes this assignment.

Although it would be possible to generate the point-to-grid-cell correspondence data during the creation of each model-compatible inventory, this method would have the disadvantage of requiring the coordinate comparison step to be repeated for every model-compatible inventory created.

If the point-to-grid-cell assignment step is performed manually using the techniques described in Section 5.3, the resulting correspondence data will still have to be incorporated into either the point source records or a machine-readable correspondence file, as described previously, in order to be utilized by the programs that create the model-compatible inventory. The manual approach, as mentioned previously, has the disadvantage of being much more time-consuming if numerous point source assignments are necessary.

Some [illegible] do not require that elevated point sources be assigned to grid cells (in [illegible] point source locations are identified by UTM coordinates). In these models, preprocessor programs are available that make this assignment based on the point [illegible] from the annual, county-level inventory. If this is the case, point-to-grid-cell correspondences need not be determined for these particular sources. Generally, however, since the modelers may not know in advance which sources will be considered as elevated, and since computerized assignments will be practiced in most instances, little extra effort will be expended in simply making this assignment for all point sources. Thus, this information will always be available in case it is needed at a later date.

The hour-by-hour point source emissions required by the photochemical model are estimated by applying seasonal, daily, and hourly operating factors to the annual emissions, as discussed in Section 5.4. In the data handling system, the temporal factors and the resulting hourly emissions can be stored either in the individual point source records (if space is available) or in a separate file created for this purpose. A potential disadvantage of storing hourly emissions on each point source record is that a great deal of file space is required. An alternative is to have the program that creates the modeling inventory compute hourly emissions at the point source level but accumulate hourly emissions at the grid cell level.

In the UAM EPS, temporal distribution data are stored in each point source data record either as profile codes (see Tables 5-4 and 5-5) or as hourly distribution factors (using the day-specific Modeling Emissions Record Format shown in Table 5-3. Temporal adjustments (except for the weeks/year adjustment discussed in Section 5.3) are not actually applied to the point source emissions until the UAM EPS program CENTEMS. CENTEMS also combines all low-level emissions (i.e., emissions from sources not selected for elevated treatment) for each grid cell by Carbon Bond species, reducing file space requirements for the final modeling inventory.

Note that when emissions from different sources are combined, the VOC and NO_x splits used to allocate these emissions to chemical classes must be applied before the emissions are summed for each grid cell in order to maintain the pollutant split identity of each source category. Hourly emissions and pollutant splits must be recomputed each time a modeling inventory is created. An example of a file containing temporal factors for individual sources is shown in Table 5-8. The entries for such a file, which are used to estimate hourly emission rates from annual emissions, are determined using the procedures outlined in Section 5.4. Different temporal patterns can be simulated (e.g., in projection inventories) by simply changing the factors in this file to reflect anticipated operating rate changes.

Data handling requirements for the speciation data used to allocate VOC and NO_x emissions into chemical classes are discussed in Chapter 9.

TABLE 5-8. Example temporal factor file for individual point sources (excerpt).

Source		Temporal Factors[c]						Code[d]
SCC[a]	Pt[b]							
30200000	02			27.0				S
30200000	02	1.43						D
30200000	02	2.29	2.29	2.29	2.29	2.29	2.29	1H
30200000	02	2.78	3.21	3.92	4.58	5.23	5.23	2H
30200000	02	5.23	5.23	5.23	5.23	5.23	5.23	3H
30200000	02	5.23	5.23	5.23	5.23	5.23	3.76	4H
30200000	03			32.0				S
30200000	03	1.76						D
30200000	03	2.99	2.99	2.99	2.99	2.99	2.99	1H
30200000	03	2.99	3.63	4.28	4.28	4.28	5.00	2H
30200000	03	5.77	5.77	5.77	5.77	5.77	5.00	3H
30200000	03	4.28	4.28	4.28	4.28	3.63	2.99	4H

[a] Plant identification by SCC code (eight digits).

[b] Point source identification by number within plant. (Note that state, county and plant IDs are not shown and should be included for complete identification.) Six successive lines constitute one point source record.

[c] Definitions: Seasonal, percentage of annual activity occurring during chosen quarter-year; daily, percentage of seasonal activity occurring on selected day; hourly, percentage of daily activity occurring on selected hour. Six consecutive hourly values appear on one line.

[d] Code: S, seasonal; D, daily; 1H, hourly, 0001 to 0600; 2H, 0601 to 1200; 3H, 1201 to 1800; 4H, 1801 to 2400.

References for Chapter 5

1. The 1985 NAPAP Emissions Inventory (Version 2): Development of the Annual Data and Modeler's Tapes, EPA-600/7-89-012a, Air and Energy Engineering Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1989.

2. Love, R. A., and Mann, C. O., The Use of the AIRS Facility Subsystem for the Management of Emissions Inventory Data, presented at the 83rd Annual Meeting & Exhibition of the Air & Waste Management Association, Pittsburgh, PA, June 1990.

3. Procedures for the Preparation of Emission Inventories for Precursors of Ozone, Volume I, EPA-450/4-88-021, U.S. Environmental Protection Agency (OAQPS), December 1988.

4. Breathing Loss Emissions from Fixed-Roof Petrochemical Storage Tanks (Draft), EPA Contract No. 68-02-2815, Work Assignment No. 6, Engineering-Science, Inc., July 1978.

5. Compilation of Air Pollution Emission Factors, Fourth Edition and Supplements, AP-42, U.S. Environmental Protection Agency, September 1985.

6. BEA Regional Projections to 2040, Volume 1: States, U.S. Department of Commerce, Bureau of Economic Analysis, June 1990.

7. User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System, EPA-450/4-90-007D, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1990.

6 AREA SOURCES

6.1 GENERAL

The emissions modeler can often use an existing, county-level area source emission inventory as the basis for the modeling inventory, with the possible exception of emissions from mobile sources (which are discussed separately in Chapter 7), especially if the county-level inventory was prepared in accordance with the guidelines given in Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone: Volume I.[1] The existing inventory will usually contain collective emissions estimates at the county level for those sources considered too minor and/or too numerous to be handled individually in the point source inventory. In addition to small stationary sources, the county-level area source inventory often includes emissions from off-highway mobile sources, such as aircraft, locomotives, and off-road vehicles. As an example of a source classification scheme used to identify types of sources in the inventory, Table 6-1 lists the area source category designations currently used in the NAPAP inventory along with the photochemically reactive pollutants commonly inventoried for each category.

Table 6-2 contains additional area source category designations which the UAM EPS uses to distinguish between the exhaust, evaporative, refueling, and running loss components of motor vehicle emissions (this distinction must be maintained for accurate speciation of VOC emissions from these sources into chemical classes). Chapter 7 discusses the use of these additional categories.

The area source categories listed in Table 6-1 include all of the area sources addressed in Volume I, although Volume I separates several of these source categories into subcategories, as noted in Table 6-3. If the county-level area source inventory includes estimates for the subcategories shown in this table, the emissions modeler may wish to maintain this distinction in the modeling inventory, especially if detailed local data are available for these sources.

Some of the source categories listed in Table 6-1 may be treated as point sources in the existing inventory; other source categories may be represented in both the point and area source inventories, depending on the emissions cutoff level used to make this distinction. Likewise, a number of other source categories traditionally inventoried as point sources may, at least in part, be treated as area sources (e.g., industrial fuel use, industrial surface coating, and gasoline bulk tanks). The emissions modeler should be aware of all such

TABLE 6-1. NAPAP area source categories and inventoried ozone precursor pollutants.

Code	Description	VOC	CO	NO_x
Stationary Source Fuel Use				
1	Residential Fuel - Anthracite Coal	X	X	X
2	Residential Fuel - Bituminous Coal	X	X	X
3	Residential Fuel - Distillate Oil	X	X	X
4	Residential Fuel - Residual Oil	X	X	X
5	Residential Fuel - Natural Gas	X	X	X
6	Residential Fuel - Wood	X	X	X
7	Commercial/Institutional Fuel - Anthracite Coal	X	X	X
8	Commercial/Institutional Fuel - Bituminous Coal	X	X	X
9	Commercial/Institutional Fuel - Distillate Oil	X	X	X
10	Commercial/Institutional Fuel - Residual Oil	X	X	X
11	Commercial/Institutional Fuel - Natural Gas	X	X	X
12	Commercial/Institutional Fuel - Wood	X	X	X
13	Industrial Fuel - Anthracite Coal	X	X	X
14	Industrial Fuel - Bituminous Coal	X	X	X
15	Industrial Fuel - Coke	X	X	X
16	Industrial Fuel - Distillate Oil	X	X	X
17	Industrial Fuel - Residual Oil	X	X	X
18	Industrial Fuel - Natural Gas	X	X	X
19	Industrial Fuel - Wood	X	X	X
20	Industrial Fuel - Process Gas	X	X	X
96	Minor Point Sources - Coal Boilers	X	X	X
97	Minor Point Sources - Oil Boilers	X	X	X
98	Minor Point Sources - Gas Boilers	X	X	X
99	Minor Point Sources - Other	X	X	X
Solid Waste Disposal				
21	On-Site Incineration - Residential	X	X	X
22	On-Site Incineration - Industrial	X	X	X
23	On-Site Incineration - Commercial/Institutional	X	X	X
24	Open Burning - Residential	X	X	X
25	Open Burning - Industrial	X	X	X
26	Open Burning - Commercial/Institutional	X	X	X
Highway Mobile Sources				
27	Light-Duty Gasoline Vehicles - Limited Access Roads	X	X	X
28	Light-Duty Gasoline Vehicles - Rural Roads	X	X	X
29	Light-Duty Gasoline Vehicles - Suburban Roads	X	X	X
30	Light-Duty Gasoline Vehicles - Urban Roads	X	X	X
31	Medium-Duty Gasoline Vehicles - Limited Access Roads	X	X	X
32	Medium-Duty Gasoline Vehicles - Rural Roads	X	X	X
33	Medium-Duty Gasoline Vehicles - Suburban Roads	X	X	X
34	Medium-Duty Gasoline Vehicles - Urban Roads	X	X	X
35	Heavy-Duty Gasoline Vehicles - Limited Access Roads	X	X	X
36	Heavy-Duty Gasoline Vehicles - Rural Roads	X	X	X
37	Heavy-Duty Gasoline Vehicles - Suburban Roads	X	X	X
38	Heavy-Duty Gasoline Vehicles - Urban Roads	X	X	X

continued

TABLE 6-1. Continued.

Code	Description	VOC	CO	NO_x
40	Heavy-Duty Diesel Vehicles - Limited Access Roads	X	X	X
41	Heavy-Duty Diesel Vehicles - Rural Roads	X	X	X
42	Heavy-Duty Diesel Vehicles - Suburban Roads	X	X	X
43	Heavy-Duty Diesel Vehicles - Urban Roads	X	X	X
Nonhighway Mobile Sources				
39	Off Highway Gasoline Vehicles	X	X	X
44	Off Highway Diesel Vehicles	X	X	X
45	Railroad Locomotives	X	X	X
46	Aircraft Landings and Takeoffs - Military	X	X	X
47	Aircraft Landings and Takeoffs - Civil	X	X	X
48	Aircraft Landings and Takeoffs - Commercial	X	X	X
49	Vessels - Coal	X	X	X
50	Vessels - Diesel Oil	X	X	X
51	Vessels - Residual Oil	X	X	X
52	Vessels - Gasoline	X	X	X
Other Combustion Sources				
60	Forest Wild Fires	X	X	X
61	Managed Burning - Prescribed	X	X	X
62	Agricultural Field Burning	X	X	X
63	Frost Control - Orchard Heaters	X	X	X
64	Structural Fires	X	X	X
VOC EVAPORATIVE SOURCES				
Gasoline Distribution				
54	Gasoline Marketed	X		
103	Bulk Terminals and Bulk Plants	X		
Stationary Source Solvent Use				
78	Degreasing	X		
79	Dry Cleaning	X		
80	Graphic Arts/Printing	X		
81	Rubber and Plastics Manufacture	X		
82	Architectural Coatings	X		
83	Auto Body Repair	X		
84	Motor Vehicle Manufacture	X		
85	Paper Coating	X		
86	Fabricated Metals	X		
87	Machinery Manufacture	X		
88	Furniture Manufacture	X		
89	Flatwood Products	X		
90	Other Transportation Equipment Manufacture	X		
91	Electrical Equipment Manufacture	X		
92	Shipbuilding and Repairing	X		
93	Miscellaneous Industrial Manufacture	X		
95[b]	Miscellaneous Solvent Use	X		

continued

TABLE 6-1. Concluded.

Code	Description	VOC	CO	NO_x
101	Cutback Asphalt Paving Operation	X		
102	*Fugitives from Synthetic Organic Chemical Manufacture*	X		
104	Fugitives from Petroleum Refinery Operations	X		
105	Process Emissions from Bakeries	X		
106	Process Emissions from Pharmaceutical Manufacture	X		
107	Process Emissions from Synthetic Fibers Manufacture	X		
108	Crude Oil and Gas Production Fields	X		
Waste Management Practices				
100	Publicly Owned Treatment Works (POTWs)	X		
109	Hazardous Waste Treatment, Storage, and Disposal	X		
PARTICULATE AND AMMONIA SOURCES				
55	Unpaved Road Travel			
56	Unpaved Airport LTOs			
66	Ammonia Emissions - Light-Duty Gasoline Vehicles			
67	Ammonia Emissions - Heavy-Duty Gasoline Vehicles			
68	Ammonia Emissions - Heavy-Duty Diesel Vehicles			
69[c]	Livestock Waste Management - Turkeys			
70[c]	Livestock Waste Management - Sheep			
71[c]	Livestock Waste Management - Beef Cattle			
72[c]	Livestock Waste Management - Dairy Cattle			
73[c]	Livestock Waste Management - Swine			
74[c]	Livestock Waste Management - Broilers			
75[c]	Livestock Waste Management - Other Chickens			
76	Anhydrous Ammonia Fertilizer Application			
77	Beef Cattle Feed Lots			

[a] Category 53 is disaggregated into process categories 78 to 95.

[b] Formerly "miscellaneous industrial solvent use" (94) and "miscellaneous non-industrial solvent use" (95); now combined into one category (95).

[c] These categories formerly referred to as "manure field application."

source: Reference 2 concluded

TABLE 6-2. Additional Area Source Category Descriptions for mobile sources for use with the UAM EPS.

Exhaust emissions:		**Refueling emissions:**	
27	Light-Duty Gasoline Vehicles - Limited Access	327	Light-Duty Gasoline Vehicles - Limited Access
28	Light-Duty Gasoline Vehicles - Rural Roads	328	Light-Duty Gasoline Vehicles - Rural Roads
29	Light-Duty Gasoline Vehicles - Suburban Roads	329	Light-Duty Gasoline Vehicles - Suburban Roads
30	Light-Duty Gasoline Vehicles - Urban Roads	330	Light-Duty Gasoline Vehicles - Urban Roads
31	Medium-Duty Gasoline Vehicles - Limited Access	331	Medium-Duty Gasoline Vehicles - Limited Access
32	Medium-Duty Gasoline Vehicles - Rural Roads	332	Medium-Duty Gasoline Vehicles - Rural Roads
33	Medium-Duty Gasoline Vehicles - Suburban	333	Medium-Duty Gasoline Vehicles - Suburban
34	Medium-Duty Gasoline Vehicles - Urban Roads	334	Medium-Duty Gasoline Vehicles - Urban Roads
35	Heavy-Duty Gasoline Vehicles - Limited Access	335	Heavy-Duty Gasoline Vehicles - Limited Access
36	Heavy-Duty Gasoline Vehicles - Rural Roads	336	Heavy-Duty Gasoline Vehicles - Rural Roads
37	Heavy-Duty Gasoline Vehicles - Suburban Roads	337	Heavy-Duty Gasoline Vehicles - Suburban Roads
38	Heavy-Duty Gasoline Vehicles - Urban Roads	338	Heavy-Duty Gasoline Vehicles - Urban Roads
39	Off-Highway Gasoline Vehicles	339	Off-Highway Gasoline Vehicles
40	Heavy-Duty Diesel Vehicles - Limited Access	340	Heavy-Duty Diesel Vehicles - Limited Access
41	Heavy-Duty Diesel Vehicles - Rural Roads	341	Heavy-Duty Diesel Vehicles - Rural Roads
42	Heavy-Duty Diesel Vehicles - Suburban Roads	342	Heavy-Duty Diesel Vehicles - Suburban Roads
43	Heavy-Duty Diesel Vehicles - Urban Roads	343	Heavy-Duty Diesel Vehicles - Urban Roads
44	Off-Highway Diesel Vehicles	344	Off-Highway Diesel Vehicles
Evaporative emissions:		**Running loss emissions:**	
227	Light-Duty Gasoline Vehicles - Limited Access	427	Light-Duty Gasoline Vehicles - Limited Access
228	Light-Duty Gasoline Vehicles - Rural Roads	428	Light-Duty Gasoline Vehicles - Rural Roads
229	Light-Duty Gasoline Vehicles - Suburban Roads	429	Light-Duty Gasoline Vehicles - Suburban Roads
230	Light-Duty Gasoline Vehicles - Urban Roads	430	Light-Duty Gasoline Vehicles - Urban Roads
231	Medium-Duty Gasoline Vehicles - Limited Access	431	Medium-Duty Gasoline Vehicles - Limited Access
232	Medium-Duty Gasoline Vehicles - Rural Roads	432	Medium-Duty Gasoline Vehicles - Rural Roads
233	Medium-Duty Gasoline Vehicles - Suburban	433	Medium-Duty Gasoline Vehicles - Suburban
234	Medium-Duty Gasoline Vehicles - Urban Roads	434	Medium-Duty Gasoline Vehicles - Urban Roads
235	Heavy-Duty Gasoline Vehicles - Limited Access	435	Heavy-Duty Gasoline Vehicles - Limited Access
236	Heavy-Duty Gasoline Vehicles - Rural Roads	436	Heavy-Duty Gasoline Vehicles - Rural Roads
237	Heavy-Duty Gasoline Vehicles - Suburban Roads	437	Heavy-Duty Gasoline Vehicles - Suburban Roads
238	Heavy-Duty Gasoline Vehicles - Urban Roads	438	Heavy-Duty Gasoline Vehicles - Urban Roads
239	Off-Highway Gasoline Vehicles	439	Off-Highway Gasoline Vehicles
240	Heavy-Duty Diesel Vehicles - Limited Access	440	Heavy-Duty Diesel Vehicles - Limited Access
241	Heavy-Duty Diesel Vehicles - Rural Roads	441	Heavy-Duty Diesel Vehicles - Rural Roads
242	Heavy-Duty Diesel Vehicles - Suburban Roads	442	Heavy-Duty Diesel Vehicles - Suburban Roads
243	Heavy-Duty Diesel Vehicles - Urban Roads	443	Heavy-Duty Diesel Vehicles - Urban Roads
244	Off-Highway Diesel Vehicles	444	Off-Highway Diesel Vehicles

source: Reference 3

TABLE 6-3. **Comparison of NAPAP area source categories and subcategories used in Procedures for the Preparation of Emission Inventories for Precursors of Ozone, Volume I (EPA,1988).**

NAPAP Code and Description	Volume I Subcategories
54 Gasoline marketing	Tank Truck unloading (Stage 1) Vehicle refueling (Stage II) Underground tank breathing Gasoline tank trucks in transit
78 Degreasing	Open top and conveyorized degreasing Cold cleaning degreasing
39 Off-highway gasoline vehicles, 44 Off-highway diesel vehicles	Off-highway motorcycles Farm equipment Construction equipment Industrial equipment Lawn and garden equipment Snowmobiles

distinctions for the existing inventory and may need to institute certain changes to ensure that the modeling inventory meets the modeling objectives. The following example illustrates a case where such changes may be appropriate.

- In order to make a detailed analysis of the effect of controlling dry cleaning operations, the emissions modeler may choose to treat each facility individually as a point source rather than collectively as an area source to facilitate evaluation of distinct control measures for each facility. Conversely, if the existing inventory treats dry cleaning facilities as point sources, but the emissions modeler cannot obtain specific information on anticipated growth at specific locations, the emissions modeler may wish to treat dry cleaning as an area source in the modeling inventory.

In most cases, however, the same point and area source distinctions employed in the existing inventory should be maintained in the modeling inventory to minimize additional resource requirements.

The emissions estimates available from the existing inventory usually represent annual or (in some cases) seasonal emissions for a fairly broad geographical area, such as for each county within an urban area, primarily because the estimates of activity levels used to calculate area source emissions are generally available at the county level. Generally, these emissions estimates will not distinguish between different reactive classes of VOC and NO_x.

Nevertheless, the area source emissions contained in the existing inventory can often be used in the modeling inventory. In order to provide the spatial, temporal, and chemical resolution required of the modeling inventory, the emissions modeler must perform the following tasks:

- allocate county-level emission estimates for area sources to modeling grid cells;

- develop hour-by-hour emission estimates for the episode days; and

- apportion VOC emissions for each source into chemical classes (and, in some models, distinguish NO_x emissions as NO and NO_2).

Sections 6.2 and 6.3 describe techniques for providing the necessary spatial and temporal resolution in the modeling inventory, respectively. Section 6.4 addresses projection of area source emissions estimates. Procedures for speciating area source emissions into chemical classes are discussed in Chapter 9.

Remember that the only emissions to be disaggregated by the procedures described below are area source totals. If some of the sources in any category have been listed and treated as either major or minor point sources, the emissions modeler must subtract the emissions from those sources from the county-level category total before applying the disaggregation procedures. If available local information allows a major fraction of the emissions to be treated as minor point sources for both the base year and the projection years, such handling may be advantageous. However, if the number of such sources is minor and their aggregate emissions are inconsequential, or if the necessary projection information is inadequate, subdivision of the area source category into area and point components may not be worth the additional effort required.

6.2 GENERAL METHODOLOGY FOR SPATIAL RESOLUTION

County-level area source emissions estimates can be apportioned to grid cells using either of two approaches. In certain cases, determining the activity levels and emissions of some area sources directly for each grid cell may be feasible. More commonly, the emissions modeler must apportion county-level emissions by assuming that the distribution of the area source activity behaves similarly to some spatial surrogate indicator. Both approaches are discussed below.

6.2.1 Direct Grid Cell Level Determination of Emissions

In limited cases, the emissions modeler may possess sufficient information to calculate area source activity levels and emissions directly for each grid cell. For instance, enough data may be available for individual facilities that they could have been considered as minor point sources in the existing inventory; however, for various reasons, a decision has been made to consider these sources collectively as an area source. Two examples are given below:

- A local gas company has information on the quantity of natural gas fired in every household or commercial establishment, allowing direct calculation of emissions by grid cell.

- Survey results are available for a particular type of commercial or industrial establishment; for instance, a survey may have been conducted resulting in information on the sales and location of each gasoline service station in the modeling region. Instead of aggregating gasoline sales and calculating emissions at the county level (as may be done in the annual inventory), gasoline sales can be aggregated and emissions calculated for individual grid cells.

If survey information similar to that described in the example above is available, the emissions modeler may wish to "reassign" each facility as a point source in the modeling inventory. This course might be particularly advantageous if a certain control measure under consideration for implementation can best be evaluated by treating each facility within the affected source category as a point source. This method, however, requires that many additional point source records be generated and maintained in both the base year and projection inventories, an obvious disadvantage. In projection inventories, handling numerous small establishments as area sources rather than as point sources will usually be easier, especially if the emissions modeler does not have information regarding the location of each facility in the projection years.

6.2.2 Surrogate Indicator Approach

If the approach described above for directly determining area source activity levels and emissions for each grid cell is infeasible, the emissions modeler must implement some other apportioning scheme to spatially allocate the emissions in the county-level area source inventory. The most straightforward approach would be to distribute the total emissions for each county evenly over all grid cells in the county; this approach, however, defeats the purpose of using a sophisticated grid model like the UAM. Instead, the usual method employed to spatially distribute emissions to sub-county regions involves the use of various combinations of spatial surrogate indicators.

A spatial surrogate indicator is a parameter whose distribution is known at a subcounty level and which behaves similarly to the activity levels of interest. Commonly used spatial surrogate indicators include land use parameters, employment in various industrial and commercial sectors, population, and dwelling units. Different surrogate indicators should be used to apportion emissions for the various area source categories, of course, depending on which of the available indicators best describes the spatial distribution of the emissions. The emissions modeler should employ engineering judgment to select appropriate indicators for apportioning area source emission totals and should consult local authorities to verify the applicability of the source category/spatial surrogate indicator pairings for that particular modeling region.

- For example, fugitive emissions from crude oil and gas production fields in southern California can be distributed using range land as a spatial surrogate indicator. In Baton Rouge, Louisiana, however, the spatial distribution of emissions from these sources may be more accurately represented by using wetlands as a spatial surrogate indicator.

Table 6-4 lists example spatial surrogate indicators for area source categories, as utilized in various urban areas. These indicators can be used to spatially apportion emissions from these source types in the absence of more detailed data; however, the emissions modeler

TABLE 6-4. Example spatial allocation factor surrogates for area source categories.

Category ID	Surrogate Indicator	Emissions Category
1	Housing	Residential Fuel - Anthracite Coal
2	Housing	Residential Fuel - Bituminous Coal
3	Housing	Residential Fuel - Distillata Oil
4	Housing	Residential Fuel - Residual Oil
5	Housing	Residential Fuel - Natural Gas
6	Housing	Residential Fuel - Wood
7	Urban Land	Commercial/Institutional Fuel - Anthracite Coal
8	Urban Land	Commercial/Institutional Fuel -Bituminous Coal
9	Urban Land	Commercial/Institutional Fuel -Distillate Oil
10	Urban Land	Commercial/Institutional Fuel - Residual Oil
11	Urban Land	Commercial/Institutional Fuel - Natural Gas
12	Urban Land	Commercial/Institutional Fuel - Wood
13	Urban Land	Industrial Fuel - Anthracite Coal
14	Urban Land	Industrial Fuel - Bituminous Coal
15	Urban Land	Industrial Fuel - Coke
16	Urban Land	Industrial Fuel - Distillate Oil
17	Urban Land	Industrial Fuel - Residual Oil
18	Urban Land	Industrial Fuel - Natural Gas
19	Urban Land	Industrial Fuel - Wood
20	Urban Land	Industrial Fuel - Process Gass
21	Housing	Incineration - Residential
22	Urban Land	Incineration - Industrial
23	Urban Land	Incineration - Commercial/Institutional
24	Housing	Open Burning - Residential
25	Urban Land	Open Burning - Industrial
26	Urban Land	Open Burning - Commercial/Institutional
27	Land Area	Light Duty Gas Vehicles - Limited Access
28	Land Area	Light Duty Gas Vehicles - Rural
29	Housing	Light Duty Gas Vehicles - Suburban
30	Urban Land	Light Duty Gas Vehicles - Urban
31	Land Area	Medium Duty Gas Vehicles - Limited access
32	Land Area	Medium Duty Gas Vehicles - Rural
33	Housing	Medium Duty Gas Vehicles - Suburban
34	Urban Land	Medium Duty Gas Vehicles - Urban
35	Land Area	Heavy Duty Gas Vehicles - Limited Access
36	Land Area	Heavy Duty Gas Vehicles - Rural
37	Housing	Heavy Duty Gas Vehicles - Suburban
38	Urban Land	Heavy Duty Gas Vehicles - Urban
39	Land Area	Off-Highway Gas Vehicles
40	Land Area	Heavy Duty Diesel Vehicles - Limited Access
41	Land Area	Heavy Duty Diesel Vehicles - Rural
42	Housing	Heavy Duty Diesel Vehicles - Suburban
43	Urban Land	Heavy Duty Diesel Vehicles - Urban
44	Land Area	Off-Highway Diesel Vehicles
45	Urban Land	Railroad Locomotives
46	Population	Aircraft - Military
47	Population	Aircraft - Civil
48	Population	Aircraft - Commercial
49	Population	Vessels - Coal-Powered
50	Population	Vessels - Diesel

continued

TABLE 6-4. Concluded.

Category ID	Surrogate Indicator	Emissions Category
51	Population	Vessels - Residual Oil
52	Population	Vessels - Gasoline
54	Population	Gasoline Marketed
55	Land Area	Unpaved Roads
56	Land Area	Unpaved Airstrips
60	Composite Forest	Forest Wild Fires
61	Composite Forest	Managed Burning - Prescribed
62	Agricultural Land	Agricultural Field Burning
64	Housing	Structural Fires
66	Land Area	Ammonia Emissions - Light Duty Gasoline Vehicles
67	Land Area	Ammonia Emissions - Heavy Duty Gasoline Vehicles
68	Land Area	Ammonia Emissions - Heavy Duty Diesel Vehicles
69	Agricultural Land	Livestock Waste Management - Turkeys
70	Agricultural Land	Livestock Waste Management - Sheep
71	Agricultural Land	Livestock Waste Management - Beef Cattle
72	Agricultural Land	Livestock Waste Management - Dairy Cattle
73	Agricultural Land	Livestock Waste Management - Swine
74	Agricultural Land	Livestock Waste Management - Broilers
75	Agricultural Land	Livestock Waste Management - Other Chickens
76	Agricultural Land	Anhydrous NH_3 Fertilizer Application
77	Agricultural Land	Beef Cattle Feed Lots
78	Population	Degreasing
79	Population	Drycleaning
80	Population	Graphic Arts/Printing
81	Population	Rubber and Plastic Manufacturing
82	Population	Architectural Coating
83	Population	Auto Body Repair
84	Population	Motor Vehicle Manufacturing
85	Population	Paper Coating
86	Population	Fabricated Metals
87	Population	Machinery Manufacturing
88	Population	Furniture Manufacturing
89	Population	Flat Wood Products
90	Population	Other Transportation Equipment Manufacturing
91	Population	Electrical Equipment Manufacturing
92	Population	Ship Building and Repair
93	Population	Miscellaneous Industrial Manufacturing
95	Population	Miscellaneous Solvent Use
96	Population	Minor Point Sources - Coal Combustion
97	Population	Minor Point Sources - Oil Combustion
98	Population	Minor Point Sources - Natural Gas Combustion
99	Population	Minor Point Sources - Process Sources
100	Population	Publicly Owned Treatment Works (POTWs)
101	Population	Cutback Asphalt Paving Operation
102	Land Area	Fugitives from Synthetic Organic Chemical Mfg.
103	Population	Bulk Terminal and Bulk Plants
104	Population	Fugitives from Petroleum Refinery Operations
105	Population	Process Emissions from Bakeries
106	Population	Process Emissions from Pharmaceutical Mfg.
107	Population	Process Emissions from Synthetic Fibers Mfg.
108	Population	Crude Oil and Natural Gas Production Fields
109	Population	Hazardous Waste Treatment, Storage and Disposal Facilities (TSDFs)

source: Reference 2

concluded

should make a special effort to choose spatial surrogate indicators for the various source categories which accurately reflect the distribution of activity for those sources in the modeling region. Specifically, emissions from non-highway mobile sources (such as railroad locomotives, aircraft, etc.) should be allocated only to those grid cells in which such activity occurs; this will be discussed in greater detail later in this chapter. Table 6-5 lists specific references which contain useful information for developing spatial resolution for several source categories; other sources, which will be addressed in detail below, include land use patterns (from maps and/or computerized data bases) and Census Bureau demographic statistics by traffic zone or census tract.

Developing Apportioning Factors from Land Use Patterns. For most urban areas, land use data will be available for the present and several projection years; the emissions modeler can use this data to develop apportioning factors for those area sources whose emissions will be distributed based on various land use classifications. Although spatial apportioning factors can be developed manually from maps, computerizing as many steps of this process as possible generally minimizes the required effort. Unfortunately, computerized land use data may be unavailable for projection years, an obvious drawback. In this case, the computerized land use data base can be used to develop apportioning factors for the base year emissions inventory, and projected changes in land use patterns accounted for in projection year apportioning factor files by editing the base year file. One national land use data base which can be used to determine spatial apportioning factors is described below; other sources of land use data may also be used, if available.

- The U.S. Geological Survey (USGS) maintains a comprehensive computerized national data base of land use distribution data, based upon the classification system shown in Table 6-6. The USGS data files, available in both digital and character formats, contain data for many regions of the country in terms of four hectare grid cells (200 meters x 200 meters). Items contained in the data base for each individual grid cell include UTM zone, UTM Easting and Northing, land use and land cover attribute code (Table 6-6), political unit code, USGS hydrologic code, census county subdivision or SMSA tract code, Federal land ownership agency code, and State land ownership code. Since a given modeling region will often contain over 500,000 four-hectare grid cells, manipulation of such large amounts of data is best accomplished with the aid of a computer.[4]

Regardless of the source of land use data, the same basic procedures must be followed to generate the spatial apportioning factor file. First, the grid cells within each county must be identified, as illustrated conceptually in Figure 6-1; in this figure, the shaded area in the upper map has been approximated with shaded grid cells in the lower grid. Figure 6-2 designates the grid cell assignments for each county in the modeling region for the Atlanta, Georgia area. In this figure, the large numbers along the southern and western

TABLE 6-5. Additional sources of information for spatial resolution of emissions for selected area source categories.

Source Type	References
Aircraft, commercial	FAA Air Traffic Activity Reports (Annual), U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C. Airport Activity Statistics for Certified Route Air Carriers (Annual), U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C.
Aircraft, general	Census of U.S. Civil Aircraft (Annual), U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C.
Aircraft, military	Military Air Traffic Report (Annual), U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C.
Agricultural equipment	Census of Agriculture, Volume I, Area Reports (Annual), U.S. Department of Commerce, Bureau of the Census, Washington, D.C.
Off-highway motorcycles	Motorcycle Statistical Annual, Motorcycle Industry Council, Inc., Newport Beach, CA.
Railroad locomotives	Transportation maps of various states, prepared by U.S. Geological Survey for the Office of Policy and Program Development, Federal Railroad Administration, United States Department of Transportation.
Vessels (ocean-going, river cargo, and small pleasure craft)	Waterborne Commerce of the United States, (Annual), U.S. Army Corps of Engineers, Washington, D.C.
Gasoline handling	Census of Business Selected Services Area Statistics, U.S. Department of Commerce, Bureau of the Census, Washington, D.C.
Fuel combustion, commercial/institutional	Sales of Fuel Oil and Kerosene, Mineral Industry Surveys.

TABLE 6-6. Land use classification system used in USGS land use data bases.

1.	**URBAN OR BUILT-UP LAND**	**5.**	**WATER**
11	Residential	51	Streams and canals
12	Commercial and Service	52	Lakes evergreen
13	Industrial	53	Reservoirs
14	Transportation, communication and services	54	Bays and estuaries
15	Industrial and commercial complexes	**6.**	**WETLAND**
16	Mixed urban or built-up land	61	Forested wetland
17	Other urban or built-up land	62	Nonforested wetland
2.	**AGRICULTURAL LAND**	**7.**	**BARREN LAND**
21	Cropland and pasture	71	Dry salt flats
22	Orchards, groves, vineyards, nurseries, and ornamental horticultural groves	72	Beaches
		73	Sandy areas, other
		75	Strip mines, quarries, and gravel pits
23	Confined feeding operation	76	Transitional areas
24	Other agricultural land	77	Mixed barren land
3.	**RANGELAND**	**8.**	**TUNDRA**
31	Herbaceous rangeland	81	Shrub and brush tundra
32	Shrub and brush rangeland	82	Herbaceous tundra
33	Mixed rangeland	83	Bare ground
		84	Wet tundra
		85	Mixed tundra
4.	**FOREST LAND**	**9.**	**PERENNIAL SNOW OR ICE**
41	Deciduous forest land	91	Perennial snow fields
42	Evergreen forest land	92	Glaciers
43	Mixed forest land		

source: Reference 4

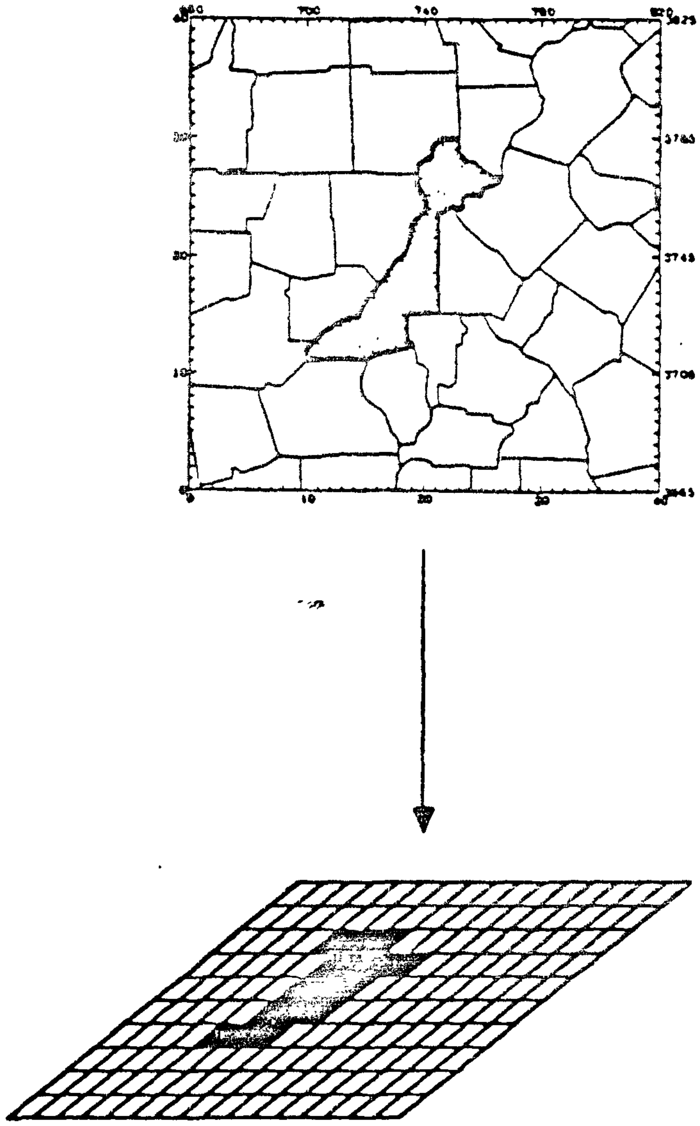


FIGURE 6-1. Conceptual representation of the grid cell identification process.

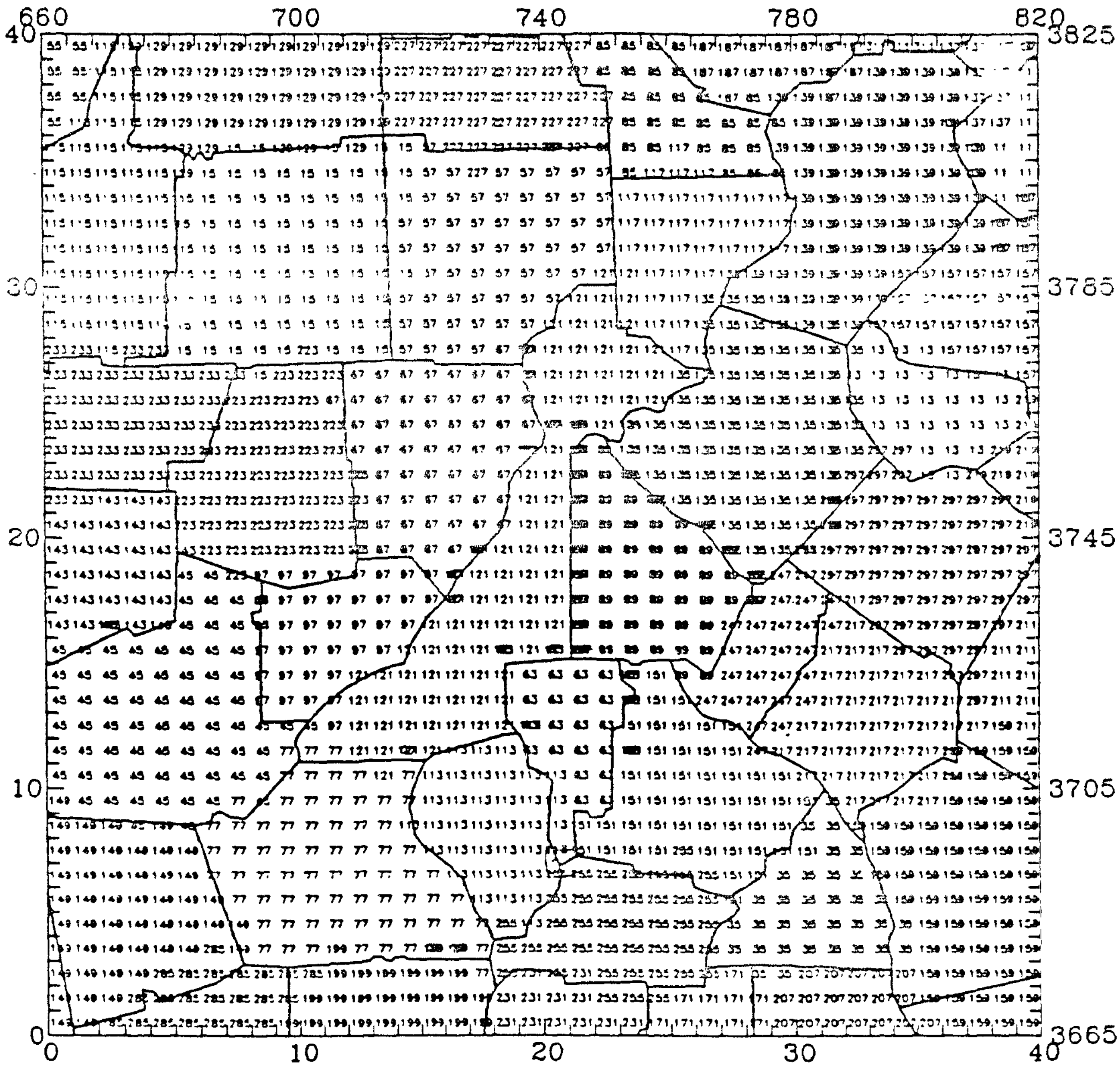


FIGURE 6-2. County grid cell assignments for the Atlanta, Georgia modeling region.

boundaries of the modeling region represent grid cell (I,J) modeling coordinates; the large numbers along the northern and eastern boundaries are UTM coordinates. The small numbers located within each grid cell of the map itself are geographical codes denoting each county. Within each grid cell in the county, the fraction of the total county land use for each land use category must then be calculated. Note that several land use categories may contribute to the total land use for any given cell; similarly, more than one county can contribute to the total area within a grid cell, as shown in Figure 6-2 by the overlap of numerical codes in those grid cells comprising the county borders.

The following example illustrates a manual procedure for developing gridded spatial apportioning factors from maps. In general, the procedures outlined below can also be computerized; likewise, computerized data bases and data base systems such as geographical information systems (GIS) can be used to develop spatial apportioning factors, allowing complete automation of the spatial allocation process.

- Assume that the existing inventory contains an estimate of total emissions from dry cleaning for the entire study area and that no specific survey or other information is available for individual dry cleaning establishments. The emissions modeler must select a spatial surrogate indicator that will permit distribution of emissions to the individual grid cells in the study area. Land use maps, which cartographically characterize each part of the study area in terms of what kinds of activities are predominant in that area, are often available from local planning agencies. Figure 6-3 shows a land use map of part of the Tampa Bay, Florida region. The various areas are identified in great detail by numbers; Table 6-7 shows the coding system used in this application. Other land use maps may use colors or shading techniques to differentiate areas.

  Since dry cleaning is a typical commercial activity, a reasonable assumption is that dry cleaning area source emissions emanate uniformly from the commercial areas as shown on the land use map. Thus, the spatial surrogate indicator will be the area devoted to commercial land use (represented in Figure 6-3 by codes 12 and 15). In this approach, the area within each grid cell designated as a commercial area on the land use map must be estimated. For this purpose, the grid system network must be superimposed on the land use map, as shown in Figure 6-3. The estimates of land use area in a grid cell can be fairly rough (e.g., to the nearest tenth of a grid cell). As an example, consider the grid cell designated (15,15) in Figure 6-3. For this grid cell, about 20 percent of the area is indicated as commercial (code number 12), while the remaining 80 percent of the grid cell is designated as single-family residential (code number 11). If a grid cell contains an area designated by code number 15 (industrial and commercial combined), such an area may be weighted at 50 percent in this computation.

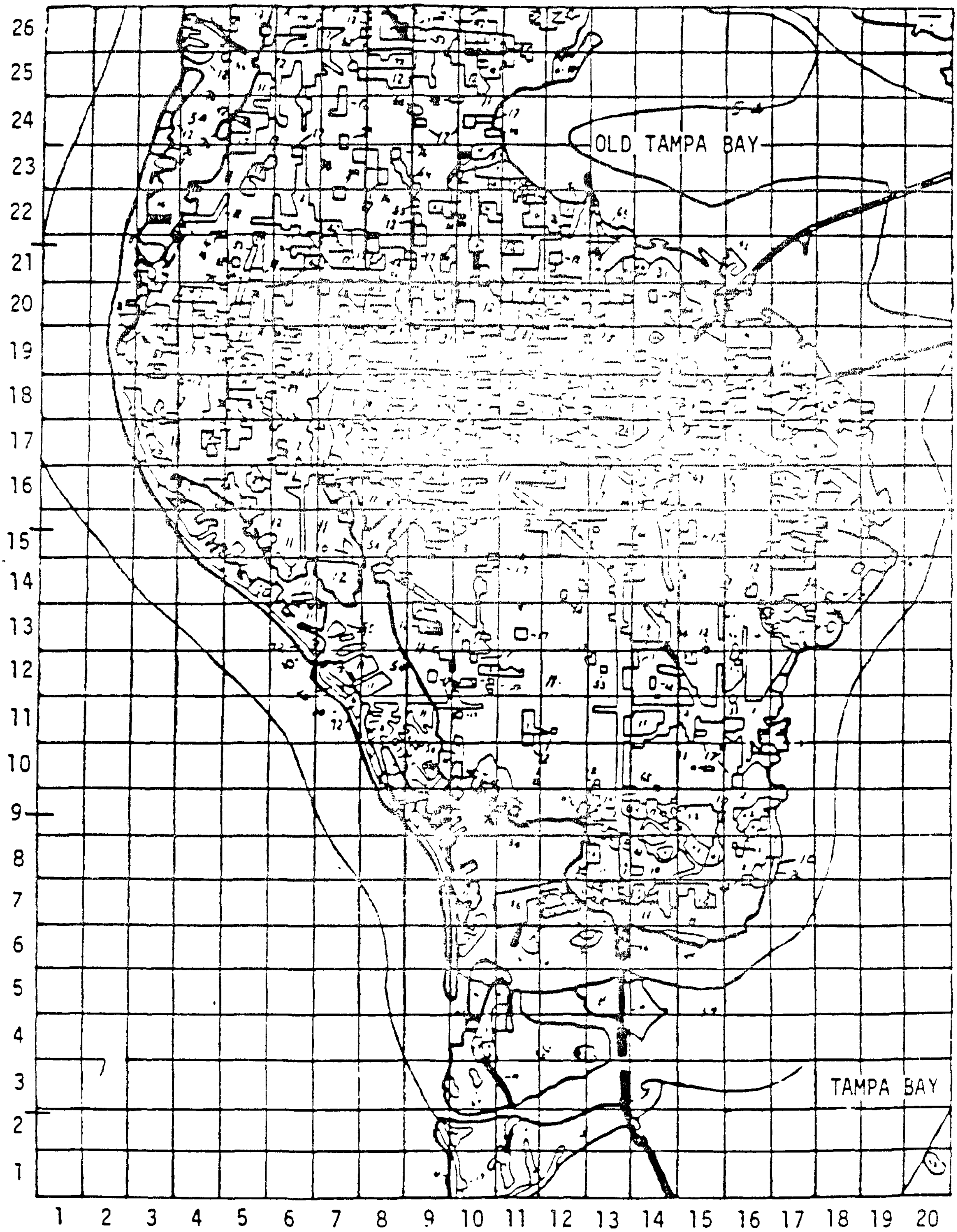


FIGURE 6-3. Segment of land use map for Tampa Bay, Florida.

TABLE 6-7. Land use categories for Tampa Bay area land use map (Figure 6-3).

1. URBAN OR BUILT-UP LAND	**4. FOREST LAND**
10 Multi-family residential	41 Deciduous forest land
11 Single family residential	42 Evergreen forest land
12 Commercial and service	43 Mixed forest land
13 Industrial	
14 Transportation, communication and utilities	**5. WATER**
15 Industrial and commercial combined	51 Streams and canals
16 Mixed urban or built-up land	52 Lakes
17 Other urban or built-up land	53 Reservoirs
	54 Bays and estuaries
2. AGRICULTURAL LAND	**6. WETLAND**
23 Confined feeding operation	63 Freshwater forested wetland
24 Other agricultural land	64 Freshwater marsh
25 Cropland	65 Saltwater forested wetland
26 Improved pasture	66 Saltwater marsh
27 Specialty farms	
28 Orchards, groves, vineyards, nurseries, and ornamental horticultural groves	**7. BARREN LAND**
29 Citrus groves	72 Beaches
	73 Sandy areas other than beaches
	75 Extractive
3. RANGELAND	76 Transitional areas
31 Herbaceous rangeland	
32 Shrub and brush rangeland	
33 Mixed rangeland	

source: Reference 5

The emissions for each grid cell are then estimated as a simple fraction of the total, as follows:

$$E_i = E_T (S_i / S_T) \qquad (6\text{-}1)$$

where E denotes emissions, S indicates surrogate indicator, i indicates the value in grid cell i, and T indicates the total for the county or region.

The units for the surrogate indicator can be arbitrary (e.g., percent of grid cell, square kilometer, square mile). For example, assume that the total *commercial area in Figure 6-3* covers an area the size of 26.3 grid cells. Then the fraction of the total commercial area (S_i / S_T) for grid cell (15,15) will be 0.2/26.3, or 0.0076. (This fraction is known as a "apportioning factor.") Thus, the emissions for dry cleaning attributed to grid cell (15,15) will be 0.0076 times the total dry cleaning emissions from the entire region. Mathematically, this can also be expressed by Equation 6-2,

$$f_{i,k} = S_{i,k} / \Sigma_{i=1}^{n} (S_{i,k}) \qquad (6\text{-}2)$$

where $f_{i,k}$ is the apportioning factor for grid cell i with respect to source category k, and n is the total number of grid cells.

The emissions modeler can also use other maps, if reasonably current, to develop apportioning factors for various area sources.

- United States Geological Survey (USGS) maps show the location of oil and gas wells. By counting the number of wells per grid cell, total oil and gas well emissions can be apportioned by multiplying the total emissions for each county by the fraction of the total number of wells in each grid cell. (In this case, the number of wells serves as the surrogate indicator of product or activity). Similarly, USGS maps show railroad track mileage, which may be used to develop apportioning factors for railroad emissions.

Often, the most representative way to spatially distribute emissions from some off-highway mobile sources, such as railroad locomotives, aircraft, and vessels, is to treat these sources as "line" sources. Emissions from these sources can be assumed to occur only in those grid cells that contain railroad track mileage, airports, or waterways. The UAM EPS program GRDEMS will distribute emissions to grid cells using user-specified link data. Specifically, GRDEMS allocates the emissions associated with each type of link (e.g., railroad track mileage) to each grid cell based on the fraction of the total county link distance for the link type occurring in that grid cell. Section 7.6, regarding spatial distribution of highway mobile source emissions, contains additional information on the specification of link data for use with the UAM EPS.

One disadvantage of developing apportioning factors from maps other than land use maps is that the corresponding projection information for allocating future year emissions will often be unavailable. In these cases, the emissions modeler will either have to (1) assume that projection year spatial emission patterns for these sources will not change, or (2) locate additional information that shows what changes are expected in the spatial surrogate indicator distributions.

The foregoing discussion dealt only with the allocation of area source emissions based on a single surrogate indicator. In some cases, no one parameter may accurately describe the subcounty distribution of emissions from a particular area source category. In this situation, apportioning factors can be based on two or more surrogate indicators.

- Since miscellaneous solvent use can be associated with both consumer (residential) and commercial applications, the emissions modeler may wish to distinguish between the possible different rates of use in these land use categories (10, 11, and 12 of Table 6-7).

The emissions modeler can use either one of two principal methods to perform this apportionment. First, solvent emission subtotals can be estimated for the three types of land use involved, and each of these subtotals apportioned according to the corresponding subcategories (in effect, this creates three new emission subcategories which replace the one contained in the county-level inventory).

- One third of miscellaneous solvent emissions may be assigned to multifamily residences (land use 10), one third to single family residences (land use 11), and one third to commercial and service use (land use 12). Hence, if county-level emissions from miscellaneous solvent use are 12 tons per day, 4 tons per day would be apportioned at the grid cell level for each of these subcategories, based on the distribution of the corresponding surrogate indicator.

Alternatively, the emissions modeler might decide to estimate the level of activity associated with each land use category.

- Assuming single-family residential areas have the smallest emission rate per unit area, the emissions modeler might estimate that the emission rate in multiple family residential areas is three times as large as in single-family residential areas, and in commercial and service areas, five times as large. In this case, the apportioning factors would be calculated using an appropriate weighting factor for each of the three types of land use. This would be expressed, mathematically, by the equation

$$f_{ik} = (\Sigma^{3}_{j=1} W_{jk}S_{ij}) / [\Sigma^{n}_{i=1} (\Sigma^{3}_{j=1} W_{jk}S_{ij})] \quad (6\text{-}3)$$

where W_{jk} is the weighting factor selected for land use type j in relation to source category k, and S_{ij} is the value of the surrogate indicator (i.e., the area) of land use type j in cell i.

The summation term appearing in the numerator above is essentially a composite surrogate indicator for the entire category. Thus, if solvent emissions are weighted according to the previous suggestion ($W_1 = 1$, $W_2 = 3$, $W_2 = 5$) and the respective areas in a given grid cell are 0.6, 0.2, and 0.2, then the value of the composite surrogate indicator for that cell is (0.6 x 1) + (0.2 x 3) + (0.2 x 5), or 2.2. The entire category is then apportioned as usual, based on this composite surrogate indicator.

Developing Apportioning Factors from Demographic Statistics at the Traffic Zone Level. As part of the transportation planning process routinely performed in larger urban areas, employment and other demographic statistics are aggregated at the zonal level. These statistics can be used instead of (or in addition to) land use patterns to obtain the information needed to apportion area source emissions to the subcounty level.

In theory, these zonal statistics contain the same data available from land use maps or data bases; thus, the only difference in using one approach or the other is procedural. In practice, however, typically available land use data are often less detailed than the zonal statistics. For instance, zonal statistics in a particular urban area may be compiled for five or more commercial and industrial subcategories; however, the corresponding land use data may only identify generalized commercial and industrial land use.

To manually develop apportioning factors from land use maps, the emissions modeler must code the land use data for each grid cell; this step must be repeated for every growth projection. Using zonal statistics, however, allows this process to be largely automated once a set of zone-to-grid-cell conversion factors has been developed. These conversion factors are discussed later in this section. The data handling aspects of utilizing zonal statistics are addressed in more detail in Section 6.5.

The following example illustrates the use of detailed zonal statistics for developing allocation factors as well as the use of multiple surrogate indicators to apportion emissions from a given area source category.

- In the San Francisco Bay Area of California, emissions from 58 area sources are apportioned using combinations of the 19 demographic parameters shown in Table 6-8, all of which are compiled at the subcounty level by the local MPO as part of transportation planning studies. For some area source categories, a single parameter from Table 6-8 is used as a surrogate indicator of the distribution of emissions. For instance, the source category "farming operations" is linked with the single employment category "AGRI" from Table 6-8, which includes agriculture production and services. Similarly, the source category "printing" is distributed with the variable "MFGI," which includes printing, publishing, and related industries.

  The spatial distribution of emissions from other area source categories, however, cannot be accurately represented using a single variable. In these cases, emissions are apportioned based on two or more parameters. Table 6-9 presents an excerpt from a cross-classification table used in the Bay Area; this table shows the percentage of each area source emission total that is apportioned by each demographic parameter listed in Table 6-8.

  Assume that area source degreasing emissions in a given county are 42 tons/day of VOC. According to Table 6-9, 10 percent of this total should be apportioned based on manufacture of electrical and optical machinery and instruments employment (MFG4), 60 percent based on fabricated metal product employment (MFG5), 20 percent based on retail service employment (RET SERV.), and 10 percent based on other services employment, which includes local transit and transportation services (OTHER SERV.). Thus, 4.2 ton/day (42 x 0.10) are apportioned according to the fraction, in each grid cell, of the total number of employees in the "MFG4" category; 25.2 ton (42 x 0.60) are apportioned according to the fraction, in each grid cell, of the total number of employees in the "MFG5" category; 8.4 ton (42 x 0.20) apportioned according to the fraction of employees in each grid cell in the "RET. SERV." category; and 4.2 ton (42 x 0.10) apportioned according to the fraction of "OTHER SERV." employees in each grid cell. For example, if the i^{th} grid cell contains 0.1 percent of the total area-wide "MFG5" employees, 0.05 percent of the "RET. SERV." employees, 1 percent of the "MFG4" employees, and no "OTHER SERV." employees, then the degreasing emissions would be apportioned to that grid cell as follows:

  $$i^{th} \text{ Grid Cell Emissions} = 25.2(0.001) + 8.4(0.0005) + 4.2(0.01) + 4.2(0) = 0.0714 \text{ ton/day}$$

  The degreasing emissions for the other grid cells would be apportioned similarly, as would the emissions for the other area sources. An equivalent formulation of this procedure is simply to subdivide the area source

TABLE 6-8. Demographic parameters used in San Francisco Bay Area for making zoneal allocations of area sources.

Variable[a] Name	SIC[b] Classification	Description
DWELL	(not applicable)	Dwelling units
AGR,	1, 7-9	Agriculture, forestry
[illegible]	10, 13, 14	Mining, quarry, oil and gas extraction
MFG1	27	Printing, publishing
MFG2	26, 28, 29, 32, 33	Petroleum, chemical, paper, and metal industries
MFG3	20	Food and kindred products
MFG4	19, 36, 38	Electrical, optical, machinery and instruments
MFG5	34, 35, 37	Fabricated metal products
MFG6	22-25, 31, 39	Textiles, apparel, wood, leather
TRAN	40, 42, 44-46	Transportation (non-auto), pipelines
WHOL	50, 52	Wholesale trade, building material
FIN	62, 63, 67	Financial, insurance
SERV 1	73	Business services
SERV 2	82, 84, 89	Educational services, museums, galleries
GOV	91, 92	Government
RET	53-59	General merchandise and food stores
BUS. SERV.	80, 81, 96	Health, legal, administrative services
RET. SERV	70, 72, 75-79	Hotels, personal service, repairs
OTHER SERV.	15-17, 41, 47-49, 60, 61, 66, 93-95, 99	Construction, transit, utilities, banking, real estate, other

[a] The variable referred to is the employment, totaled in each zone, for the SIC classifications listed in the next column (DWELL is an exception, as described in Column 3).

[b] Standard Industrial Classification Code

source: Reference 6

TABLE 6-9. Excerpt from ABAG cross classification table used in San Francisco Bay Area for subcounty allocation of area source activities.

Source Classification	1 Dwell	7 Agri	8 Min	9 Mfg1	10 Mfg2	11 Mfg3	12 Mfg4	13 Mfg5	14 Mfg6	15 Tran	16 Whol	17 Fin	18 Serv1	19 Serv2	20 Gov	21 Ret	22 Bus Serv	23 Ret Serv	24 Serv Other
CHEMICAL																			
Misc. Chem. Proc																			
OTHER IND./COM.																			
Metallurgical					90			10											
Mineral - Concrete					100														
Mineral - Stone, Sand &	10		40		60														
Mineral - Sand Blast					10			5		10	5	5	5	10	10	10	10	10	10
Misc. Mineral Proc.			10		90														
Farming Operations		100																	
Food/Agricultural Proc.						100													
Paint Spray Mist	5				10			70										15	
Wood Products Mfg.	10								80									10	
Misc. Inc./Com. Proc.							30	30	30									10	
GASOLINE DISTRIBUTION																			
Vehicle Fill Station -																			
- Spillage										5						90			5
- Storage Tanks										5						90			5
- Vehicle Tanks										5						90			5
OTHER ORG. COMP.																			
Storage Tanks -																			
- Solvent					20		20	20	20	10	5							5	
- Misc. Org. Comp		5	10		20	15	10	10	10	10	5								5
Ind Coat. - Solv. Base				10	10		10	50	10									10	
Ind. Coat. - Water Base								90	5									5	
Com. & Dom. Coat.																			
- Solv. Base	64	3	3							3	3	3	3	3	3	3	3	3	3
- Water Base	64	3	3							3	3	3	3	3	3	3	3	3	3
Degreasers							10	60										20	10
Drycleaners - PERC																		100	
Drycleaners - Misc.																		100	
Rubber Fabrication					100														
Plastic Fabrication					90													10	
Printing				100															
Misc. Org. Evap	10	5	5		50		5	5	5									10	5

source: Reference 6

90098 06''

degreasing category into four subcategories, namely, (1) degreasing, MFG4; (2) degreasing, MFG5; (3) degreasing, RET SERV.; and (4) degreasing, OTHER SERV. Then, if the emissions modeler has estimated the total county-level degreasing emissions for these subcategories as 4.2, 25.2, 8.4, and 4.2 ton per day, respectively, these amounts will be allocated in the appropriate subcategories, using the corresponding demographic parameter as the surrogate indicator in each case.

The preceding apportioning calculation assumes that apportioning factors are compiled at the grid cell level. In actuality, as mentioned at the outset of this section, the spatial surrogate indicators (such as the demographic parameters shown in Table 6-8) used for apportioning are initially compiled at the zonal level for transportation and other planning purposes rather than at the grid cell level. For example, the San Francisco Bay area local MPO develops its population, land use, and employment data for 440 zones, each of which comprises one to seven census tracts. By contrast, there are some 5,000 grid cells to which area source emissions are apportioned for photochemical modeling purposes.

Thus, use of zonal statistics to apportion area source emissions requires that the emissions modeler determine a zone-to-grid-cell conversion before completing the apportioning steps. This step is unnecessary when apportioning factors are manually developed from land use maps, since in that method the grid system is overlaid onto the land use map and the values of each surrogate indicator are directly determined for each grid cell by visual means.

To determine a zone-to-grid-cell conversion, the emissions modeler must (1) overlay a map outlining the grid system over a map showing the zone boundaries (or perform the computer-assisted equivalent) and (2) determine or estimate fractions of zonal area lying within specific grid cells.

A zone-to-grid-cell correspondence table like the one shown in Table 6-10 facilitates this procedure. For each zone, the area falling in each grid cell is estimated in terms of the fraction (A) of the grid cell covered by that zone; the total of these fractional areas for all of the affected grid cells (SA) is the total area of the zone (note the exception that occurs when part of the zone lies outside the emission grid). The following example illustrates the calculations involved in determining the zone-to-grid cell correspondence.

- For each grid cell, the appropriate fraction (g) of the given zone is obtained by dividing the area of intersection by the total area of the zone. The contribution of the zonal emissions to the grid square can be obtained by multiplying the zonal emissions (in any or all categories) by this fraction.

TABLE 6-10. Illustrative excerpts from zone-to-grid-cell correspondence table for determining apportioning factors.

Zone										Total, ΣA
1	GC A g	(01,01) 1.0 .19	(01,02) 1.0 .19	(01,03) 0.7 .13	(02,01) 1.0 .19	(02,02) 0.5 .10	(03,01) 0.7 .13	(04,01) 0.3 .06		5.2
2	GC A g	(01,03) 0.3 .08	(01,04) 1.0 .26	(02,02) 0.5 .13	(02,03) 1.0 .26	(02,04) 0.6 .15	(03,01) 0.2 .05	(03,03) 0.2 .05	(03,04) 0.1 .03	3.9
17	GC A g	(05,14) 0.6 1.0								0.6
18	GC A g	(05,14) 0.1 0.33	(06,14) 0.2 0.67							0.3
23	GC A g	(06,24) 0.3 0.33	(06,25) 0.6 0.67							0.9

Legend:

GC = Grid Cell
A = Area of intersection of zone with grid cell
g = Apportioning factor from zonal level to grid cell (all activities assumed uniform throughout zone)

90098 06''

Next, the fractions (g) are multiplied by the known zonal values of each demographic parameter to aggregate the data at the grid cell level. Mathematically, this process may be expressed as follows:

$$a_{ik} = \Sigma_j \, g_{ij} b_{jk} \qquad (6\text{-}4)$$

where a_{ik} is the value of the k^{th} demographic parameter, aggregated to grid cell i; b_{jk} is the value of the k^{th} demographic parameter, as compiled for zone j; and g_{ij} is the areal fraction of zone j in cell i. Note that the value of g_{ij} is given by

$$g_{ij} = A_{ij} \; / \; \Sigma_i \, (A_{ij}) \qquad (6\text{-}5)$$

where A_{ij} is the fractional area of intersection of zone j with cell i, in terms of the fraction of cell i covered by zone j.

To calculate the apportioning factors (denoted by $f_{i,k}$) for allocating county-level emissions to grid cells, the grid cell level values of each demographic parameter must be normalized to the total for the county, i.e.,

$$f_{i,k} = a_{ik} \; / \; \Sigma_i \, a_{ik} \qquad (6\text{-}6)$$

The same normalizing factor can, of course, be obtained by totaling the zonal values; that is,

$$\Sigma_i \, a_{ik} = \Sigma_j \, b_{jk} \qquad (6\text{-}7)$$

except for necessary corrections for any zone which falls partly outside the county. The apportioning factors ($f_{i,k}$) are applied in the same way as the (S_i / S_T) factors (determined from land use or other maps) in Equation 6-1 that were determined from land use or other maps.

The most difficult part of the zone-to-grid-cell conversion process as described above is determining the $g_{i,j}$ fractions. This step may need to be performed manually because In the past, the often irregular nature of zonal boundaries in most urban areas complicated the computerization of this assignment; algorithms for calculating the area of irregularly shaped polygons do exist, however, and can be used in conjunction with modern digitizing techniques to facilitate this process. The rest of the calculations described above are readily automated.

- The procedures described above are also applicable for developing apportioning factors from population density data at the census tract level. Census of Population and Housing data can be extracted in computerized format from the Master Area Reference File (MARF), available from the U.S. Bureau of the Census and gridded based on the location of the centroid of each block group enumeration district (BGED). Figure 6-4 shows the locations of the BGED chondrites for a modeling region used in a UAM application for Atlanta, Georgia; note that some grid cells, particularly in the urban area of Atlanta (located at the center of the modeling region) contain numerous BGED centroids, while others in the outlying rural areas contain no centroids. Figure 6-5 shows a spatial density plot of the population data after assignment to grid cells based on the BGED centroid locations. Although the population data available from the Census Bureau will usually be somewhat outdated because of the infrequency of data compilation, the emissions modeler can still use this data to develop apportioning factors for the base year modeling inventory, provided that no significant changes in population density distributions have occurred.

When estimating the $g_{i,j}$ fractions, which represent the areal fractions by grid cell for each demographic parameter, the emissions modeler should keep in mind the implicit assumption that the distribution of each demographic parameter is uniform within each zone. In situations where the zones are much larger than the coincident grid cells, this assumption can lead to erroneous distributions if most activity within a particular zone actually takes place in some subportion of that zone. Hence, before using the values in the zone-to-grid cell correspondence table to apportion emissions, the emissions modeler should submit the table to review by local planners or others knowledgeable with the land use patterns in the urban area. In select cases, the emissions modeler may elect to distribute more activity to one or more grid cells than would be assigned based solely on area. Since zones are defined as areas of similar activity, however, this will seldom require major consideration from the emissions modeler.

6.3 GENERAL METHODOLOGY FOR TEMPORAL RESOLUTION

Since the basic area source inventory usually contains estimates of annual (or perhaps seasonally adjusted) emissions, the emissions modeler must expend additional effort to estimate hour-by-hour emission rates for the episode days. Several approaches can be employed to develop hourly emissions resolution; all involve the use of assumed diurnal patterns of activity. In addition to hourly patterns, estimates of seasonal fractions of annual activity will be needed if the county-level inventory is not seasonally adjusted. Activity profiles by day of week will also be required.

If the county-level inventory contains annual emission estimates, the first step is to estimate the seasonal components of activity for each area source. Chapter 6 of Volume I discusses seasonal adjustment in detail. For many sources, activity is fairly constant from season to season. Table 6-11 lists recommended seasonal adjustment factors for selected

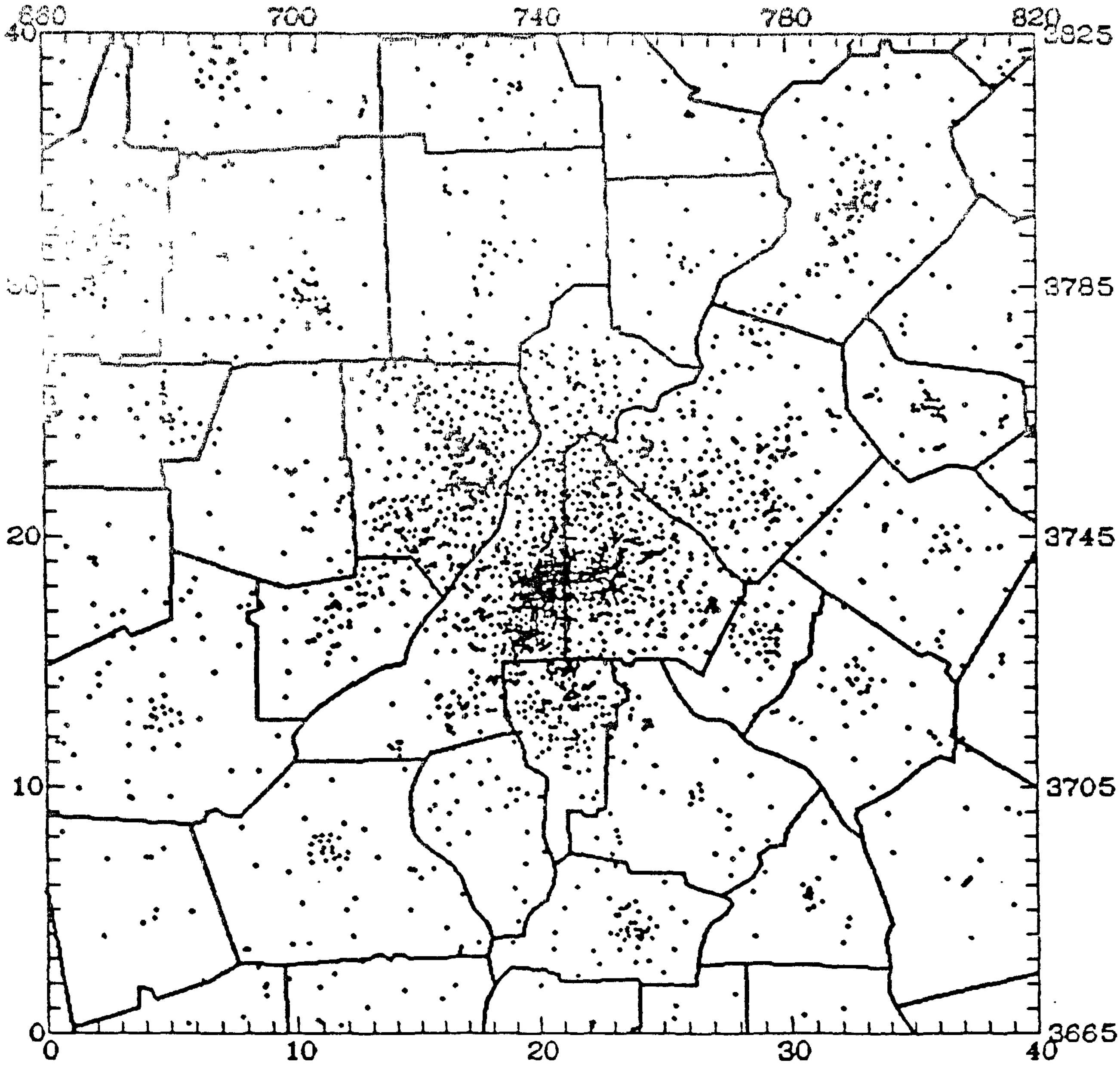


FIGURE 6-4. Location of block group enumeration centroids for the Atlanta, Georgia modeling region.

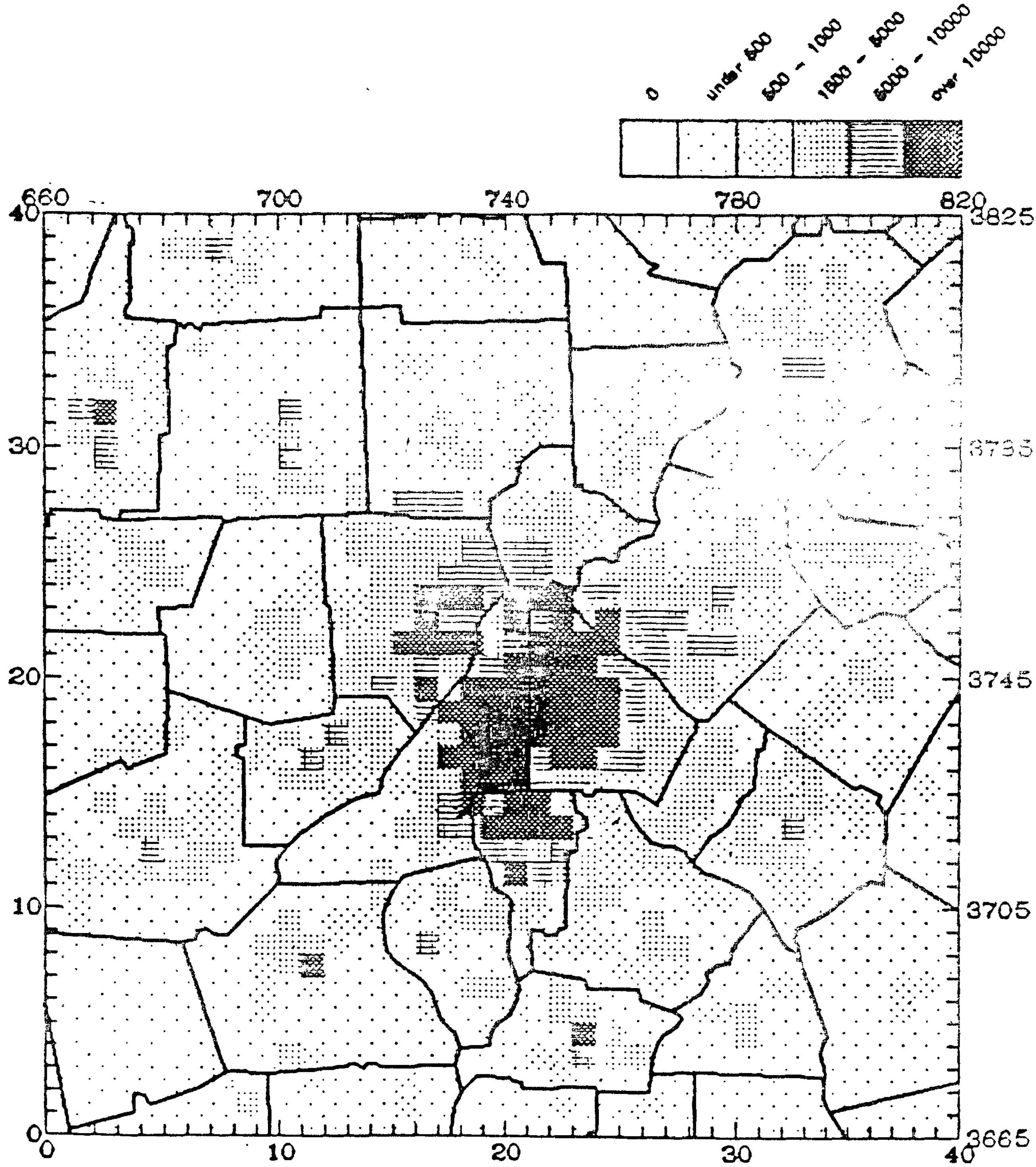


FIGURE 6-5. Sample gridded population data for the Atlanta, Georgia modeling region.

TABLE 6-11. Ozone season adjustment factors for selected area source categories.

Category	Seasonal Adjustment Factors
Gasoline Service Stations	
Tank trucks in transit	Seasonal variations in throughput vary from area to area. Use average temperature for a summer day where appropriate.
Tank truck unloading (Stage I)	
Vehicle refueling (Stage II)	
Storage tank breathing losses	
Solvent Users	
Degreasing	Uniform
Drycleaning	Uniform
Surface coatings	
Architectural	1.3
Auto refinishing	Uniform
Other small industrial	Uniform
Graphic arts	Uniform
Cutback asphalt	0
Pesticides	1.3
Commercial/consumer	Uniform
Waste Management Practices	
POTWs	1.4
Hazardous waste TSDFs	1.2
Municipal landfills	Uniform
Stationary Source Fuel Combustion	
Residential	0.3
Commercial/institutional	0.6
Industrial	Uniform
Solid Waste Disposal	
On-site incineration	Uniform
Open burning	Refer to local regulations and practices
Structural fires	Uniform
Field/slash/prescribed burning	0
Wildfires	Refer to local fire conditions
Off-highway Mobile Sources	
Agricultural equipment	1.1
Construction equipment	Uniform
Industrial equipment	Uniform
Lawn and garden equipment	1.3
Motorcycles	1.3

source: Reference 1

area source categories. If local activity distribution data is unavailable, the emissions modeler can use these factors to seasonally adjust the emissions in the annual inventory.

The UAM EPS program GRDEMS assigns temporal distribution codes and monthly activity factors by source category code. The cross-reference file used to make these assignments requires that seasonal adjustment factors be defined as monthly fractions of annual activity. The seasonal adjustment factors in Table 6-11 can be converted to monthly fractions for use in this file in the manner described below.

For each month of the ozone season (usually summer), the monthly fraction of annual activity for a particular source category will be the seasonal adjustment factor for that category divided by 12. For example, the seasonal adjustment factor in Table 6-11 for architectural surface coating is 1.3; accordingly, the monthly fraction will be (1.3) / (12), or 0.108. For the other months, the monthly fraction can be assumed to be 1/9 of the remaining activity, or [1 - (3 x monthly fraction for an ozone season month)] / 9. In the current example, this corresponds to a monthly fraction of [1 - (3 x 0.108)] / 9, or 0.075.

If the inventory contains seasonal emission estimates, the emissions modeler should ensure that no additional seasonal adjustment is applied by using a flat monthly variation profile for all source categories (i.e., each month factor would be (1) / (12), or 0.083.

Once the seasonal adjustment is known, the weekly variation must be determined. Again, some area source activities are fairly constant from day to day, making it a simple matter to estimate daily activities. For example, gasoline storage losses and natural gas leaks would be expected to be uniform over the week. Many area sources, on the other hand, will generally be more active on weekdays. For instance, dry cleaning plants and degreasing operations will concentrate their activities during Monday through Friday (or Saturday, in some cases). In these cases, the seasonal activity should be distributed to only those days on which the source is active, as shown in the following example.

- Suppose dry cleaning emissions for an entire modeling region are 312 tons of solvent over the 92-day period from July to September, and most plants are typically open 6 days a week (for a total of 78 operating days). Daily emissions from dry cleaning would then be 4 tons (312 / 78). This daily emission rate would not, of course, be applicable to a Sunday. As explained in Chapter 2, photochemical models are usually run for weekday conditions.

After the daily activity level has been determined for each area source, the next step is to estimate hourly emissions. This is generally accomplished by applying a 24-hour operating pattern to the daily activity level.

- Table 6-12 shows an example of source-specific hourly activity data for gasoline service stations. As seen in this table, more gasoline is handled in the Tampa Bay area in the afternoon than other times in the day. For instance, 13 percent of the daily operation in large stations occurs from 4 to 5 o'clock; hence, 13 percent of the daily emissions from large service stations would be assigned to that particular hour in the modeling inventory.

If the emissions modeler is using the UAM EPS to develop the modeling inventory, this type of hourly operating information can be incorporated directly into the modeling inventory using the day-specific Modeling Emissions Record Format described in the preceding chapter (see Table 5-3).

The hourly operating information in Table 6-12 is an example of a case where a special survey has been made to determine diurnal operating patterns. Where resources allow, this approach is preferable for the more important area source emitters. For many smaller sources, however, engineering judgment can provide sufficiently accurate temporal factors. Table 6-13 lists some approaches that have been employed for incorporating temporal resolution for several area source categories into the detailed emissions inventory; these temporal variations in activity levels for several area source categories can be used for temporal distribution in the absence of more specific data. For temporal resolution, local working hours and seasonal activity patterns may differ from those suggested in Table 6-13. The most general default option is to assume complete temporal uniformity. However, it is usually easy to determine whether any important emitting activity takes place mainly in the summer (as opposed to the winter), on weekdays (as opposed to weekends), or in the daytime (rather than at night). When such information is available, it should be utilized, especially if important emission categories are involved.

The development of hourly area source emission estimates from annual emissions requires a great deal of repetitive data handling, and should generally be computerized. Specific area source data handling are discussed in Section 6.5.

6.4 AREA SOURCE PROJECTION PROCEDURES

Two approaches can be used for making growth projections of area source emissions. The more accurate approach involves projecting the activity levels themselves. The more common approach, however, involves the use of growth indicators to approximate the increase or decrease of each activity level. As mentioned in Chapter 5, the emissions

TABLE 6-12. Diurnal patterns for gasoline stations in Tampa Bay, in percent of daily operation.

Hour	Type of Gasoline Station[a]		
	Small	Medium	Large
6 - 7 am	5	4	8
7 - 8	6	4	8
8 - 9	6	6	8
9 - 10	5	5	7
10 - 11	6	7	2
11 - 12 noon	6	7	2
12 - 1 pm	5	7	8
1 - 2	5	7	9
2 - 3	7	6	5
3 - 4	7	7	6
4 - 5	9	8	13
5 - 6	9	8	13
6 - 7	6	8	4
7 - 8	6	7	4
8 - 9	5	3	2
9 - 10	5	3	1
10 - 11	1	2	
11 - 12 midnight	1	1	

[a] Separate diurnal distributions were analyzed for three classes of gasoline stations: (1) small, below 200,000 gal/yr throughput; (2) medium, between 200,000 and 500,000 gal/yr throughput; and (3) large, abaove 500,000 gal/yr throughput. Data are based on 1,133 gasoline stations in the Tampa Bay area.

source: Reference 5

TABLE 6-13. Example temporal resolution methodologies for selected area source categories.

Source Category	Seasonal	Daily	Hourly
Gasoline handling	varies from area to area. Use average temperatures for a summer day where appropriate	Monday through Saturday	uniform from 0800 to 2000, otherwise zero
Drycleaning	uniform	uniform Monday through Saturday	uniform from 0700 to 1800, otherwise zero
Degreasing	uniform	uniform Monday through Saturday	80% from 0700 to 1300 20% from 1800 to 2400
Nonindustrial surface coating	uniform	uniform Monday through Saturday	uniform from 0700 to 1800, otherwise zero
Cutback asphalt	uniform spring through fall	Monday through Friday	uniform from 0700 to 1800, otherwise zero
Pesticide application	coincides with growing season	uniform	daylight hours (0700 to 1800)
Miscellaneous solvent use	uniform	uniform	60% from 0700 to 1800 20% from 1800 to 2400
Aircraft, general	uniform	40% on weekends 60% on weekdays	uniform from 0700 to 2100, otherwise zero
Aircraft, commercial and military	estimate on an individual basis; contact local airport authorities, Federal Aviation Administration, and appropriate military agencies		
Agricultural equipment	uniform throughout the agricultural season	uniform	uniform from 0700 to 2100, otherwise zero
Construction equipment	20% December-February 25% March-May 30% June-August 25% September-November	Monday through Saturday	uniform from 0700 to 1900 Monday-Friday uniform from 0700 to 1200 Saturday
Industrial equipment	20% December-February 25% March-May 30% June-August 25% September-November	uniform Monday through Saturday	80% from 0700 to 1800 20% from 1800 to 2400
Lawn and garden equipment	uniform through months which have an average temperature of 38°F or higher	50% Monday-Friday 50% Saturday and Sunday	uniform from 0800 to 1800, otherwise zero
Off-highway motorcycles	base on monthly off highway fuel use	30% Monday-Friday 70% Saturday and Sunday	
Snowmobiles	base on monthly off highway fuel use	30% Monday-Friday 70% Saturday and Sunday	

continued

90098 06'[1]

TABLE 6-13. Concluded.

Source Category	Seasonal	Daily	Hourly
Small pleasure craft	uniform through months which have an average temperature of 45°F or greater	30% Monday-Friday 70% Saturday and Sunday	uniform from 0700 to 1800, otherwise zero
Railroad locomotives	uniform	uniform	70% from 0700 to 1800 30% from 1800 to 0700
Ocean-going and river cargo vessels	uniform	uniform	75% from 0700 to 1800 25% from 1800 to 0700
Residential fuel combustion	10% of emissions uniform throughout the year 90% of emissions uniform during months having an average temperature less than 68°F	uniform	uniform
Commercial and institutional fuel combustion	25% of emissions uniform throughout the year 75% of emissions uniform during months having an average temperature less than 68°F	95% Monday-Saturday 5% Sunday	90% from 0600 to 2400 10% from 2400 to 0600
Industrial fuel combustion	uniform	uniform Monday through Saturday	80% from 0700 to 1800 20% from 1800 to 2400 otherwise zero
Solid waste disposal, on-site incineration, open burning	uniform	91% Monday-Friday 9% Saturday	uniform from 0600 to 1700
Fires: managed burning, agricultural field burning, frost control (orchard heaters)	10% winter 70% spring 0% summer 20% fall	uniform	uniform from 0600 to 2100
Fires: forest wildfires, structural fires	uniform	unifrom	uniform
Waste management practices (POTWs, TSDFs)	uniform	uniform	uniform

source: References 1, 2

concluded

90098 06''

modeler should consult current EPA guidance documents on projection of future year emission inventories when identifying appropriate growth indicators for the various source categories; an updated guidance document concerning emission inventory projection techniques is scheduled for release by EPA in July, 1991.

The first of the above-mentioned approaches is generally employed when a local survey has been made or local estimates are available for projecting growth in specific areas.

- If a survey of dry cleaners has been performed and the average estimated growth in the modeling area is 5 percent per year, then in 5 years, dry cleaning activity would be projected to increase by a factor of [illegible] (a 28% increase). As another example, a local asphalt trade association may be able to project cutback asphalt usage.

When considering such estimates, the inventorying agency must recognize the possibility of deliberate or inadvertent biases due to wishful thinking or self-serving motives and should strive to obtain opinions which are as objective as possible. The agency should also be careful to determine whether or not such estimates of future activity levels reflect the effects of anticipated control measures, an important consideration since some such estimates may be more appropriately used in control strategy projections than in the baseline inventory. Most importantly, any such projections should be consistent with projections made by other planning agencies.

A common alternative to directly projecting activity levels is to use surrogate growth indicators. Use of surrogate indicators was discussed in Section 6.2 with respect to spatial allocation of area source emissions. In the context of projections, a surrogate growth indicator is one whose growth in the future is fairly certain and is assumed to behave similarly to the activity level of interest. The most commonly used surrogate growth indicators are those parameters typically projected by local MPO's, such as population, housing, land use, and employment. In the absence of local projections, the BEA economic indicators described in Section 5.5 can be used to develop growth indicators for area sources. Table 6-14 lists example growth indicators for selected area source categories. The following example illustrates use of a surrogate growth indicator to project emissions.

- The quantity of miscellaneous solvent use in a projection year might be assumed to grow proportionally with population. Hence, if population increased in an area by 10 percent from the base year to the projection year, miscellaneous solvent usage would be assumed to increase by 10 percent, as well.

Regardless of what variables are used as growth surrogates, the basic calculation is the same: the ratio of the value of the growth indicator in the projection year to its value in

TABLE 6-14. Example growth indicators for projecting emission totals for area source categories.

Source Category	Growth Indicators	Information Sources
Gasoline handling	Gasoline demand, vehicle use (VMT), or population	U.S. Department of Transportation, state transportation agency, state tax agency, local MPO
Dry cleaning	Population, retail service employment	Solvent supplier, trade association
Degreasing	Industrial employment	Trade association
Non-industrial surface coating	Population or residential dwelling units	Local MPO
Cutback asphalt	Consult industry and local road departments	Consult industry and local road departments
Pesticide application	Agricultural operations	State department of agriculture, local MPO
Miscellaneous solvent use	Population	Local MPO
Aircraft, commercial and general	Projections should be done case-by-case, projected land use maps may be useful	Local airport authority, MPO, state aviation system plan
Aircraft, military	Case-by-case	Local airport authority, appropriate military agencies
Agricultural equipment	Agricultural land use, agricultural employment	Local MPO
Construction equipment	Heavy construction employment (SIC code 16)	Local MPO
Industrial equipment	Industrial employment (SIC codes 10-14, 20-39, and 50-51) or industrial land use area	Local MPO
Lawn and garden equipment	Single-unit housing or population	Local MPO
Off-highway motorcycles, snowmobiles, and small pleasure craft	Population	Local MPO
Ocean-going and river cargo vessels	Cargo tonnage	Local port authorities, U.S. Maritime Administration, or U.S. Army Corps of Engineers
Residential fuel combustion	Residential housing units or population	Local MPO
Commercial and institutional fuel combustion	Commercial and institutional employment, population, or land use area	Local MPO, land use projections
Industrial fuel combustion	Industrial employment (SIC codes 10-14, 20-39, and 50-51) or industrial land use	Local MPO, land use projections
Solid waste disposal, on-site incineration, open burning	Based on information gathered from local regulatory agencies	
Fires: managed burning, agricultural field burning, frost control (orchard heaters)	Based on anticipated local regulations as indicated by information sources	Local MPO
Fires: forest wildfires, structural fires	Forest wildfires can be assumed to remain constant between base and projection years; project structural fires based on anticipated population growth	Local MPO

the base year is multiplied by the area source activity level in the base year to yield the projection year activity level.

A major difference between making area source projections for the county-level inventory and for the detailed modeling inventory is that, in the latter, emission estimates must be resolved at the grid cell level. This adds a dimension of complexity to the projection effort, since changing growth patterns may require determination of different apportioning factors for projection years. Fortunately, in most large urban areas where photochemical models are employed, the local MPO will be able to provide land use maps as well as detailed zonal projections of employment, population, etc., for future years. Hence, these projections can be used directly, as described above, to determine changes in spatial emission patterns.

If the surrogate indicators used for apportioning certain area source emissions are not projected at a subcounty level, engineering judgment must be used to decide whether spatial distributions of various activities will change enough to warrant the effort of identifying new patterns. Changes may be warranted in rapidly growing areas for the more important area source emitters. For regions where little growth is expected, and especially for minor area sources, the same apportioning factors can be used in baseline and projection inventories without incurring appreciable error.

In special cases, temporal factors and VOC split factors may change between the base and projection years. Temporal factors may change as lifestyles and working patterns change, or as a result of governmental policy.

- If a 4-day workweek is expected in a projection year, daily emission patterns from sources such as small degreasing operations may be altered. Likewise, if gasoline sales are prohibited on certain days or during certain hours, daily emission patterns may change.

Generally, however, the temporal patterns for most area sources will remain constant; hence, for these sources, the same daily and hourly apportioning factors can be used in the base and projection years. VOC split factors are discussed in Chapter 9.

When making area source emission projections, the emissions modeler will have to consider the effects of control measures for certain source categories. The effect of controls on area sources can generally be represented by changes in either emission factors or activity levels, depending on the source and the nature of the control measure under consideration.

As with point source projection, the area source projections should be carefully reviewed by the inventorying agency in light of all the points (i.e., objectivity, openness, etc.) discussed in Section 2.4. In particular, the emissions modeler should verify that consistent methodologies were utilized for the base and projection years to estimate and apportion emissions for each source.

- If emissions from gasoline evaporation at service stations in a base year are estimated and distributed as a result of a special study (e.g., questionnaires to individual service stations), it would be inconsistent to estimate such emissions for a future year based on projected VMT and to apportion these emissions based on the number of miles of road within each grid.

This type of methodological inconsistency will likely lead to changes in the emissions inventory that are not due to growth or control measures but, rather, to changes in the inventory procedures themselves.

As a test to determine whether different base and projection year methodologies are mutually consistent, apply the projection year methodology to the base year case and see if the results are identical. If important discrepancies exist, then one methodology should be chosen for use for both years. Generally, any methodology which applies growth factors to base year estimates to estimate projection year emissions (or activity levels) will meet this consistency criterion.

6.5 DATA HANDLING CONSIDERATIONS

The major difference between area source data handling and point source data handling concerns the way emissions are estimated at the grid cell level. Since point source locations are typically known to the nearest tenth of a kilometer, it is easy to assign them to specific grid cells. Area source emissions, however, are typically only resolved to the county (or equivalent) level in annual inventories and, thus, must be disaggregated to the grid cell level using the apportioning procedures described in Section 6.2.

Area source apportioning factors can be stored in a special file; Table 6-15 shows a sample excerpt from such a file. This file basically consists of a matrix of apportioning factor values by grid cell. In Table 6-15, the surrogate indicators are designated along the top and the grid coordinates along the side. The values in the table represent the fraction of the county-level total of each variable located within each particular grid cell. (Such a table would have to be prepared for each county for which area source emissions are resolved in the annual inventory.) In order to determine emissions from a particular area source in a given grid cell, the calculation program (1) determines what surrogate indicator is appropriate for the source in question (this information would be written into or supplied to the emission calculation routine), (2) accesses the apportioning factor file to determine what fraction corresponds to the grid cell/surrogate indicator combination in question, and then (3) multiplies that fraction by the county-level emission total for the particular area source.

TABLE 6-15. Example file of grid cell apportioning factors for area sources (excerpt)

Grid Cell Coordinates[a]	Apportioning Factors for					
	SI1[b]	SI2[b]	SI3[b]	SI4[b]	SI5[b]	SI6[b]
272,784	.001	.001	.001	.0	.004	.0
274,784	.001	.001	.001	.0	.004	.0
274,784	.001	.001	.001	.0	.004	.0
274,784	.001	.001	.001	.0	.004	.0
280,784	.001	.001	.001	.0	.003	.0
252,786	.001	.002	.002	.0	.004	.0
254,786	.011	.011	.012	.0	.0	.045
256,786	.013	.014	.015	.0	.0	.270
258,786	.001	.001	.001	.0	.004	.009
260,786	.001	.001	.001	.100	.004	.0

[a] UTM coordinates of grid cell, SW corner, Km.

[b] Apportioning factors for this example are based on the following surrogate indicators: SI1, employment; SI2, commercial employment; SI3, dwelling units; SI4, general aviation; SI5, open burning; SI6, vehicle miles traveled.

The entry in each case is the fraction of the total indicated activity which occurs in the grid cell.

The UAM EPS program GRDEMS performs the calculations described above. A cross-reference table of area source categories and spatial surrogate indicators determines which indicators are used to allocate emissions from which source categories; a user-input option allows pairing of different surrogates with source categories by county. As an example, the user can redefine the surrogate code designations for a rarely used land use surrogate (such as barren rocky with lichens) to incorporate special spatial apportioning information for one or more counties, such as detailed location data for dry cleaning establishments. Consult the User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System[3] for [illegible] requirements for the spatial [illegible]

The sequence of steps described above applies in cases where each area source category is apportioned using only one surrogate indicator. If more than one surrogate indicator must be used to accurately represent the spatial distribution of emissions for a particular area source category, the same procedure can be followed by creating new subcategories corresponding to the level of activity to be apportioned by each indicator as discussed previously. Consider the example from Section 6.2.2:

- Assume that total area source degreasing emissions of 42 tons per day of VOC are estimated to result from activity in four different sectors: MFG4 (10 percent), MFG5 (60 percent), retail service activities (20 percent), and other service activities (10 percent). The area source degreasing category can accordingly be partitioned into four subcategories, having respective totals of 4.2, 25.2, 8.4, and 4.2 tons per day. Each subcategory would then be apportioned to the grid cell level by its appropriate surrogate indicator as previously described. These subcategories would appear in the area source apportioning factor file, but not necessarily in the emissions inventory provided by the operating agency.

If area source emissions are spatially allocated based on zonal statistics on population, employment, etc., instead of land use data, a data handling procedure will be required to convert the zonal level apportioning information to the grid cell level. As discussed previously, the first steps in this process are to overlay a map showing the grid system boundaries over a map showing the zonal boundaries (the equivalent task can be performed with computer assistance), and then determine or estimate fractions of zonal areas lying within specific grid cells. These areal fractions are incorporated into a computer data file to serve as zone-to-grid-cell correspondence values. This file, in turn, can be used to generate grid cell apportioning factors by (1) multiplying the surrogate indicator values available at the zonal level (e.g., from forecasting models) by the areal fractions for each zone, (2) summing over all zones, and (3) normalizing, as shown in the equations given in Section 6.2.2. The latter steps should be computerized because of the great amount of data handling involved when hundreds of zones and grid cells are involved.

Estimating hourly area source emissions requires essentially the same data handling procedures as are described in Section 5.6 for point sources. Basically, a file of seasonal, daily, and hourly temporal factors must be created (similar in format to Table 5-8) that can be multiplied by the annual area source emissions to generate hourly emission estimates. Typically, one set of temporal operating factors will be assigned for each area source category, which are applicable for the entire modeling area. Determining appropriate temporal factors for the area source temporal factor file is a manual procedure, as described in Section 6.3.

In the UAM EPS, temporal distribution profiles for area (and mobile) sources are assigned in the GRDEMS program, based on assignments by source category contained in a cross-reference file. The temporal variation codes contained in this file correspond to those shown in Tables 5-4 and 5-5; additionally, monthly variation factors are assigned explicitly in this file. The cross-reference file provided with the UAM EPS contains temporal distribution profiles by NAPAP source category which reflect national average or default data; accordingly, the default temporal profile assignments in this file should be reviewed for local applicability, especially for significant sources.

References for Chapter 6

1. Procedures for the Preparation of Emission Inventories for Precursors of Ozone, Volume I, EPA-450/4-88-021, U.S. Environmental Protection Agency (OAQPS), December 1988.

2. NAPAP (National Acid Precipitation Assessment Program) Emissions Inventory: Overview of Allocation Factors, 1985, EPA-600/7-89-010a, Alliance Technologies Corporation, October 1989.

3. User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System, EPA-450/4-90-007D, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1990.

4. Procedures for Est[illegible] Allocating Area Source Emissions of Air Toxics, Working Draft: Appendix A, EPA Contract No. 68-02-4254, Work Assignment No. 105, Versar, Inc., Springfield, Virginia, March 1989.

5. L.G. Wayne and P.C. Kochis, Tampa Bay Area Photochemical Oxidant Study: Assessment of the Anthropogenic Hydrocarbon and Nitrogen Dioxide Emissions in the Tampa Bay Area, EPA-904/9-77-016, U.S. Environmental Protection Agency, Region IV, Air and Hazardous Materials Division, Atlanta, GA, September 1978.

6. M.C. MacCracken, User's Guide to the LIRAQ Model: An Air Pollution Model for the San Francisco Bay Area Lawrence Livermore Laboratory, UCRL-51983, Livermore, CA, 1975.

7 MOBILE SOURCE EMISSIONS

7.1 INTRODUCTION

Mobile sources of emissions include moving vehicles such as automobiles, trucks, boats, and trains. For most urban areas, emissions from mobile sources comprise a significant portion of total VOC, NO_x, and CO emissions for the region. Mobile sources are typically categorized by the following vehicle types:

- on-road vehicles;
- off-road vehicles;
- aircraft;
- railroad locomotives; and
- vessels.

On-road vehicles represent the registered vehicle fleet used in travel and transport on all road surfaces and include light duty automobiles and trucks as well as medium and heavy duty vehicles. Off-road vehicles include all recreational vehicles and machinery used in off-road situations, such as farm equipment, construction equipment, snow mobiles, off-road motorcycles, etc. Aircraft, railroad locomotives, and vessels represent all vehicles used in air, rail, and water transportation, respectively.

As mentioned in Chapter 6, an existing annual or seasonal area source emission inventory generally contains adequate estimates of emissions for all sources except on-road motor vehicles. The Urban Airshed Model will be applied for specific episode days. Mobile source emissions must be computed specifically for those days or adjusted to reflect conditions on those days. Accordingly, this chapter will focus on the special considerations necessary to develop a modeling emission inventory for on-road vehicles (other mobile sources are addressed in Chapter 6). In general, the emissions modeler may employ either one of two methods to develop the on-road vehicle portion of the modeling inventory:

(1) compiling an episode-specific on-road vehicle emission inventory using the methods described in <u>Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources</u>[3] (hereafter referred to as Volume IV); or

(2) adjusting an existing annual or seasonal inventory to reflect episodic conditions, as discussed in Section 7.3.

7.2 CHARACTERIZATION OF ON-ROAD MOTOR VEHICLE EMISSIONS

The emission factors used to estimate emissions from on-road motor vehicles vary non-linearly with a variety of parameters, including vehicle type, vehicle speed, fuel volatility, vehicle fleet characteristics, ambient temperature, diurnal temperature variations, and vehicle fleet inspection program characteristics. Accordingly, computer models such as the MOBILE series of mobile source emission factors, available from EPA's Office of Mobile Sources (EPA OMS), are commonly employed to accurately determine on-road vehicle VOC, NO_x, and CO emission factors. These emission factors (which are usually reported in terms of grams pollutant/vehicle mile traveled) are then used with an activity level (e.g., VMT) to generate on-road vehicle emissions estimates; ideally, link-specific traffic volumes and speeds will be used to generate the emission estimates. Various inventory classification schemes may then be employed to aggregate these emissions into a manageable number of categories, such as vehicle class, road type, etc., and emissions for each category will typically be reported as a county total in annual or seasonal inventories.

To facilitate accurate spatial allocation, speciation of mobile source VOC emissions, and analysis of detailed control strategies, emissions from on-road mobile sources should be reported by both vehicle type (i.e., light-duty gasoline automobiles, light-duty gasoline trucks, heavy-duty gasoline trucks, heavy-duty diesel trucks, etc.) and roadway classification (i.e., local streets and expressways). In addition to categorization by vehicle type and road class, on-road mobile source emissions should be disaggregated in terms of component emissions (exhaust, evaporative, etc.). These three types of categorization are discussed below.

7.2.1 Vehicle Classes

The registered vehicle fleet can be divided into sub-groups, or classes, such as autos, light-duty trucks, and diesel vehicles. The emission factors associated with each vehicle class will vary because of differing emission certification standards and pollution control equipment. The MOBILE models distinguish nine vehicle classes, as listed in Table 7-1, based upon gross vehicle weight (GVW) and fuel consumption type (gasoline or diesel fuel). Inventories will typically use some combination of these nine vehicle classes to report emissions.

- For example, the NAPAP inventory utilized four vehicle classes: light-duty gasoline vehicles (LDGVs), light-duty gasoline trucks (LDGTs), heavy-duty gasoline vehicles (HDGVs), and heavy-duty diesel vehicles (HDDVs). The

TABLE 7-1. Vehicle class definitions used by the MOBILE models.

Vehicle Class (Abbreviation)	GVW* Specification
Light-duty Gasoline Vehicles (LDGV)	not applicable
Light-duty Gasoline Trucks1 (LDGT1)	less than 6500 lbs.
Light-duty Gasoline Trucks2 (LDGT2)	[illegible] to 8500 lbs.
Heavy-duty Gasoline [illegible]	more than 8500 lbs.
Light-duty Diesel [illegible]	not applicable
Light-duty Diesel [illegible]	less than 8500 lbs.
Heavy-duty Diesel Vehicles (HDDV)	more than 8500 lbs.
Motorcycles (MC)	not applicable

*Gross Vehicle Weight

source: Reference 2

TABLE 7-2. Commonly used road type designations.

Rural and Urban Interstate
Rural and Urban Other Principal Arterials
Other Freeways and Expressways
Rural and Urban Minor Arterials
Rural and Urban Major Collector
Rural and Urban Minor Collector
Rural and Urban Local

LDGT category is the combination of the LDGT1 and LDGT2 categories listed in Table 7-1. Combined, these four vehicle classes total 97.6% of total on-road VMT based on national average data. The remaining vehicle classes (motorcycles and light-duty diesel trucks and vehicles) were not included in the NAPAP inventory, but should be included in inventories prepared for SIP applications.

7.2.2 Roadway Types

On-road mobile source emissions should also be distinguished by road type in the inventory. Road types [illegible] Administration (FHWA) maintains statistics are listed in Table 7-2, [illegible] commonly used in mobile emission inventories. Emission factors will vary by road type because of the variance in parameters such as speed and [illegible] with each different road types.

- For example, the NAPAP inventory reported emissions for three road types derived from the list of roadways given in Table 7-2, namely urban, rural, and limited access (separate source categories for suburban roadways are also provided, but not currently used). Table 7-3 shows the division of the road types shown in Table 7-2 into the urban, rural, and limited access categories. In the development of on-road mobile source emissions estimates, NAPAP used distinct input parameters for each road type.

7.2.3 Emission Components

In addition to the categorization of on-road mobile source emissions by road types and vehicle classes, as discussed above, emissions from these sources should be disaggregated into their components. The individual components of the on-road vehicle emissions are defined below:

- Exhaust emissions: vehicle tailpipe VOC, NO_x, and CO emissions which occur during the operation of the vehicle.

- Evaporative emissions: VOC emissions which include diurnal emissions and hot soak emissions. Diurnal emissions result from ambient temperature changes which occur when the vehicle is not in use. Hot soak emissions consist of the evaporation of emissions immediately following the end of a trip.

- Running loss emissions: evaporative VOC emissions which occur during the operation of the vehicle typically at warm temperatures and low speeds.

TABLE 7-3. NAPAP road type designations versus Federal Highway Administration (FHWA) road types.

NAPAP Road Type	Corresponding FHWA Road Types
Limited Access	Rural and Urban Interstate Rural and Urban Other Principal Arterials Other Principal Other Freeways and Expressways
Rural	Rural and Urban Minor Arterials Rural Major Collector Rural Minor Collector Rural Local
Urban	Urban Major Collector Urban Minor Collector Urban Local

source: Reference 6

- Refueling emissions: VOC emissions resulting from vapor displacement and spillage associated with vehicle refueling.

Exhaust and evaporative emissions must be differentiated because of the different characteristic VOC speciation profiles for these two categories. Additionally, emission certification standards and emission controls vary between all four groups, necessitating separation of the four components.

> The inventory classification scheme provided with the UAM EPS categorizes on-road vehicle emissions by four road type designations (limited access, urban, suburban, and rural), four vehicle classifications (LDGV, LDGT, HDGT, and HDDV), and four emission components (exhaust, evaporative, refueling losses, and running losses). Consequently, sixty-four (four road types x four vehicle classes x four emission components) source categories are defined for on-road vehicles. By contrast, the four non-on-road vehicle types are represented by eight source categories for off-road vehicles (two fuel types x four emission components), three for airplanes (military, civil, and commercial), one for railroads, and four for vessels (four fuel types), for a total of sixteen. These eighty source categories are listed in Tables 6-1 and 6-2 and are treated separately by the UAM EPS in the development of the mobile source inventory.

7.3 MOBILE EMISSION INVENTORY PROCEDURES

The on-road mobile source component of the modeling inventory may be compiled in one of two ways: (1) from original data, using the methodologies discussed in Volume IV, and (2) from an existing annual or seasonal county-level inventory such as AIRS, SAMS, or NAPAP. The first option is less infeasible than it might first appear, since the time requirements for developing an original inventory are not considerably greater than for developing the modeling inventory from an existing inventory. Additionally, the emissions modeler may only need to generate original emissions estimates for some sub-category of the mobile fleet. Some of the primary reasons for developing an original inventory include

- The mobile source emission estimates should be categorized in terms of different vehicle classes or road types than were used in the existing inventory in order to improve spatial, temporal, or chemical resolution of the modeling inventory, or to evaluate particular control strategies under consideration;

- The procedures used to develop the existing emission inventory contain uncertainties which would produce questionable model results.

Some primary reasons for developing the mobile source modeling emission inventory by adjusting an existing annual or seasonal inventory for episodic conditions are

- If emissions from mobile sources do not contribute significantly enough to the total inventory to warrant development of an inventory from original data (this is usually not the case);

- If time constraints prevent development of an original inventory; or

- *Unavailability of data such as locale-specific VMT data.*

Detailed procedures for development of mobile source emission estimates are presented in Volume IV; this document should be referred to as the definitive guidance for constructing a mobile source inventory.

If the emissions modeler decides to adjust an existing annual or seasonal mobile source emissions estimates to reflect episodic conditions, the change in emissions can be summarized by the following equation:

$$ME_E = ME_B \cdot (EF_E/EF_B) \cdot (VMT_E/VMT_B) \qquad (7\text{-}1)$$

where ME refers to mobile emissions. The subscript "B" signifies the variables associated with the existing base (i.e., annual or seasonal) inventory and the subscript "E" indicates the episode-specific variables. In Equation 7-1, the actual episode VMT and the base VMT need not be determined, but instead can be replaced by a single factor termed the "VMT factor". The VMT factor represents the VMT change between the episode and the base inventories. Note that this factor would also incorporate VMT growth if the modeling inventory is being compiled for a different year than the base inventory. Equation 7-1 thus becomes:

$$ME_E = ME_B \cdot (EF_E/EF_B) \cdot (\text{VMT Factor}) \qquad (7\text{-}2)$$

Equation 7-2 can then be incorporated into the following steps which are required to complete adjustment of the mobile inventory. The appropriate sections of this chapter containing the details of each step are indicated in parentheses:

- Determine the scenario and base inventory emission factors following the methodologies described in Volume IV for each road type and on-road vehicle class using (1) the county-level inputs used to generate the existing inventory; and (2) inputs reflecting actual episodic conditions.

- Determine the VMT factor for Equation 7-2 for each road type and vehicle class.

- Apply equation 7-2 to generate annual average mobile emissions for each county within the modeling region.

- Spatially allocate emissions (Section 7.5) to produce a gridded inventory.

- Temporally adjust the mobile emissions (Section 7.6) to reflect seasonal, daily, and hourly diurnal variations.

In a UAM EPS application, the emissions modeler should be aware of some additional adjustments assumed by the EPS: (1) the on-road refueling component of the VOC emissions is assumed to be included in the gasoline marketing area source category; and (2) the on-road VOC emission total for each vehicle class is assumed to not be disaggregated into exhaust, evaporative and running losses.

Gasoline marketing emissions are adjusted by first removing the percent of the gasoline marketing total associated with refueling emissions. In the NAPAP inventory, this percent is 47.4 %. The mobile source refueling emissions are estimated from the exhaust VOC emissions using the following equation:

$$\text{Refueling Emissions} = \text{Exhaust VOC} \cdot (EF_{REF}/EF_{EXH}) \qquad (7\text{-}3)$$

EF in this equation refers to the episodic emission factor for refueling (REF) and exhaust VOC (EXH).

The other VOC components (exhaust, evaporative and running losses) are determined by applying the following fraction to the total VOC mobile source emissions:

$$VOC_I = VOC_T \cdot (EF_I / EF_T) \qquad (7\text{-}4)$$

where the subscript "I" refers to, in turn, the exhaust, evaporative, and running losses components; the subscript "T" refers to the total VOC emissions and emission factors. From the component totals in Equation 7-4, Equation 7-2 can then be used to determine the scenario emission totals.

The PREGRD module of the UAM EPS adjusts the annual or seasonal mobile source inventory for episodic conditions. The emission factor ratios and the VMT growth factor shown in equations 7-2, 7-3, and 7-4 must be calculated outside of EPS to construct the motor vehicle factors table (also known as the "mvfacs" table) which is required input to PREGRD.

7.4 MOBILE SOURCE EMISSION FACTORS

The EPA's MOBILE series of models calculate VOC, NO_x, and CO emission factors for the on-road vehicle fleet. The current version of this model is MOBILE 4.0; an updated version, MOBILE 4.1, is scheduled for release in May 1991, and should be utilized after that date. These models incorporate the data from the EPA Surveillance Program designed to quantify and characterize the emission factors encountered in the on-road vehicle fleet. MOBILE 4.0 and 4.1 are run with a single input file containing both model parameters and user supplied information. Table 7-4 lists required input parameters. In addition to these, a list of optional parameters is given in Table 7-5. The complete definitions of the input parameters and the required format of the input file should be obtained from the user's guide for the model, available from EPA. Consult Volume IV for guidance on determining appropriate values for these inputs.

If the emissions modeler is adjusting an existing inventory, he must duplicate the emission factors used to generate the existing mobile source inventory. It is important to get the most accurate and complete information available from the documentation of the data base; if necessary, contact the developer of the existing inventory.

- Version 2 of the NAPAP inventory was compiled using MOBILE 3.9 with supplemental adjustment factors made to produce emission factors equivalent to MOBILE 4.0. The input parameters used are shown in Table 7-6. For temperatures, the NAPAP inventory utilized the annual average ambient temperature of the state with a 20 degree diurnal temperature spread. The list of annual average temperatures used is shown in Table 7-7.

Considerations For Future-Year Emission Factors. The MOBILE 4.0 and 4.1 models can be utilized for calendar years up to 2020; however, due to changing regulations (federal, state and local) for the on-road vehicle fleet, some modifications are generally required for the development of future-year emission factors. The following lists some commonly encountered situations and recommendations for their incorporation into the emission factor calculations.

Fuel Oxygenate Additives. The addition of oxygenates such as MTBE and ethanol have been used for CO reductions in winter months; however, their use has become common enough that fuel oxygenates are beginning to be used year round. With respect to ozone modeling, oxygenates generally lower exhaust VOC emissions and raise evaporative VOC emissions. Thus, it is important to determine fuel oxygen content for both current and future-year inventories. CO reductions due to oxygenates can be incorporated using a specialized version of the MOBILE model called OXY4. OXY4 is available from EPA OMS,

TABLE 7-4. Required input parameters for EPA's MOBILE models.

Calendar year
ASTM volatility class
Ambient daily temperature*
Minimum and maximum daily temperature
Base RVP
In-use RVP**
In-use RVP start year**
Region altitude
Speeds
Operating modes*

*MOBILE default values are recommended.
**Not always used by MOBILE, but input record is required.

TABLE 7-5. Optional input parameters for EPA's MOBILE models.

Alternate basic emission rates*	
Alternate vehicle tampering rates*	
Fleet Characterization Data:	
Fleet registration distribution**	
Fleet mileage accumulation**	
Diesel penetration rate**	
Vehicle class distribution**	
Inspection & Maintenance Programs:	
start year	stringency %
model years inspected	waiver rates
compliance rate	program type
frequency of inspection	vehicle classes inspected
test type	alternate credits
special mechanic training	
Anti-Tampering Programs:	
start year	model years inspected
vehicle classes inspected	program type
frequency of inspection	compliance rate
list of equipment inspected	alternate credits
Refueling Programs (Stage II):	
start year	phase-in period
LDGV % system efficiency	HDGV % system efficiency

*MOBILE default values are highly recommended.
**MOBILE default values available (national averages) but local or regional data recommended.

TABLE 7-6. MOBILE 4.0 modeling parameters used in the NAPAP inventory.

Parameter	Value or Source Used
Calendar year:	1985
ASTM volatility class:	See Volume IV
Ambient temperature:	See NAPAP documentation
Minimum temperature:	13.7°F below ambient.
Maximum temperature:	6.3°F over ambient
Base RVP:	11.5 psi.
In-use RVP:	not used.
In-use RVP start year:	not used.
Region altitude:	See Volume IV
Basic emission rates:	MOBILE 4.0 defaults.
Vehicle tampering rates:	MOBILE 4.0 defaults.
Inspection & Maintenance Programs:	County level I/M data.
Anti-Tampering Programs (ATP):	not modeled.
Stage II Refueling Programs:	n/a in 1985.
Onboard VRS (Vapor Recovery Systems):	not modeled.
Speeds:	
Urban:	19.6 mph.
Rural:	45.0 mph.
Limited access:	55 mph.
Operating modes:	
Urban:	20.6, 27.3, 20.6.
Rural:	7.0, 5.0, 7.0.
Limited Access:	0.0, 0.0, 0.0
Fleet Characterization Data:	
Fleet registration distribution:	Used county level registration data from R.L. Polk.
Fleet mileage accumulation:	MOBILE 4.0 defaults.
Vehicle class distribution:	MOBILE 4.0 defaults.

TABLE 7-7. State annual average temperatures used in the NAPAP inventory.

State	Annual Average Temp.	State	Annual Average Temp.
Alabama	62.5	Nebraska	52.6
Arizona	67.5	Nevada	67.5
Arkansas	60.0	New Hampshire	50.2
California	65.1	New Jersey	54.7
Colorado	53.9	New Mexico	58.1
Connecticut	52.2	New York	54.0
Delaware	56.2	North Carolina	60.1
District of Columbia	56.9	North Dakota	46.1
Florida	67.3	Ohio	53.8
Georgia	60.7	Oklahoma	59.3
Idaho	54.5	Oregon	56.5
Illinois	51.8	Pennsylvania	55.2
Indiana	53.6	Rhode Island	53.1
Iowa	50.2	South Carolina	62.7
Kansas	54.1	South Dakota	48.2
Kentucky	56.9	Tennessee	59.5
Louisiana	65.4	Texas	65.7
Maine	49.9	Utah	53.8
Maryland	56.6	Vermont	47.1
Massachusetts	53.0	Virginia	59.1
Michigan	51.4	Washington	55.0
Minnesota	48.3	West Virginia	57.7
Mississippi	63.2	Wisconsin	48.4
Missouri	56.2	Wyoming	51.1
Montana	50.0		

but only adjusts CO emissions. To determine VOC adjustments, the emissions modeler should consult the EPA guidance document on fuel blends.[4]

Clean Air Act Amendments. The Clean Air Act Amendments of 1990 address changes in the on-road motor vehicle fleet for ozone non-attainment areas. Included in the Amendments are discussions of the following:

- inspection and maintenance programs implementations and upgrades;
- stage II refueling programs;
- fuel reformulation (including RVP controls, fuel additives and fuel composition); and
- new vehicle emission certification standards.

The first two of these modifications can be modeled directly with the MOBILE models. For fuel reformulation effects, RVP limits are modeled; consult Reference 4 for fuel additive effects. Fuel composition changes generally will not affect emission factors, but will affect the VOC speciation profiles associated with the on-road vehicles, as discussed in Chapter 9. New emission certification standards can be incorporated into the model; however, the EPA OMS should be consulted for recommendations on the proper procedure for their incorporation.

Transportation Control Measures (TCMs). TCMs consist of a wide array of control measure which are designed for the reduction of traffic congestion. TCMs are being studied and implemented in many CMSAs. For the incorporation of TCMs into the emission inventory, a VMT reduction or speed adjustment needs to be estimated for each TCM.

7.5 SPATIAL RESOLUTION OF MOBILE SOURCE EMISSIONS

Mobile sources differ from most other area source categories in that their spatial variation is more accurately described using a link-based rather than a surrogate-based gridding procedure. Link-based spatial allocation results in distributing emissions only to those grid cells that contain transportation pathways (i.e., limited access roadways, railways, airports, shipping channels, etc.); this approach is usually used in conjunction with surrogate allocation to complete the spatial resolution of the mobile source inventory. The methodology necessary to incorporate links into the emission inventory is given in the following section (7.5.1), and the allocation of mobile emissions through surrogates is discussed in Section 7.5.2.

7.5.1 Link Surrogates

Links are used in the spatial allocation of on-road limited access vehicle, railroads, airports, and vessels emissions because the transport routes used by these vehicles are easily identifiable and can be modeled using a series of lines or links. Using links provides a more accurate allocation of emissions for these vehicles than the allocation of these emissions through other particular surrogates such as population, commercial land-use, etc.

Figure 7-1 illustrates a typical link with respect to a grid cell of an inventory. Each link is associated with a start and end point, and the length of the link in each grid cell needs to be determined. In Figure 7-1, the link shown will have three lengths calculated, the length within the grid cell, the length within the cell above the grid cell, and the length of the link in the grid cell to the right of the grid cell.

After locating all of the links of the inventory, the allocation of county total emissions to gridded emissions is performed by the following equation:

$$ME_{cell} = ME_{county} \cdot (LINK_{cell} / LINK_{county}) \qquad (7\text{-}5)$$

where ME is the mobile emission totals, the subscript county refers to county totals, the subscript cell refers to grid cell totals, and LINK refers to the total length of each link in the subscripted domain.

In the generation of links for modeling region, the following parameters need to be determined for each link:

- **Type of link**: The different types of links correspond to the different vehicle types using the link, thus the different types are limited access roadways, railroads, airports (i.e. runways), and vessels (rivers, sea lanes, and/or ports).
- **County designation**: Links need to be classified by county so that county totals can be determined. Digitized link segments should end at county borders.
- **Begin and end point coordinates:** The coordinates of the link need to be in the same units as the grid of the modeling region.

The first step in the generation of these parameters is to obtain a map with the proper links identified. The U.S. Geologic Survey (USGS) maps are a good source which clearly indicate railroads, airport runways, rivers and ports. USGS maps also use the coordinates of UTMs and latitude and longitude. It may be difficult, however, to determine motor vehicle roadway types from USGS maps, requiring the use of a more detailed street map. Note that no standard coordinate system is usually identified on street maps; reference

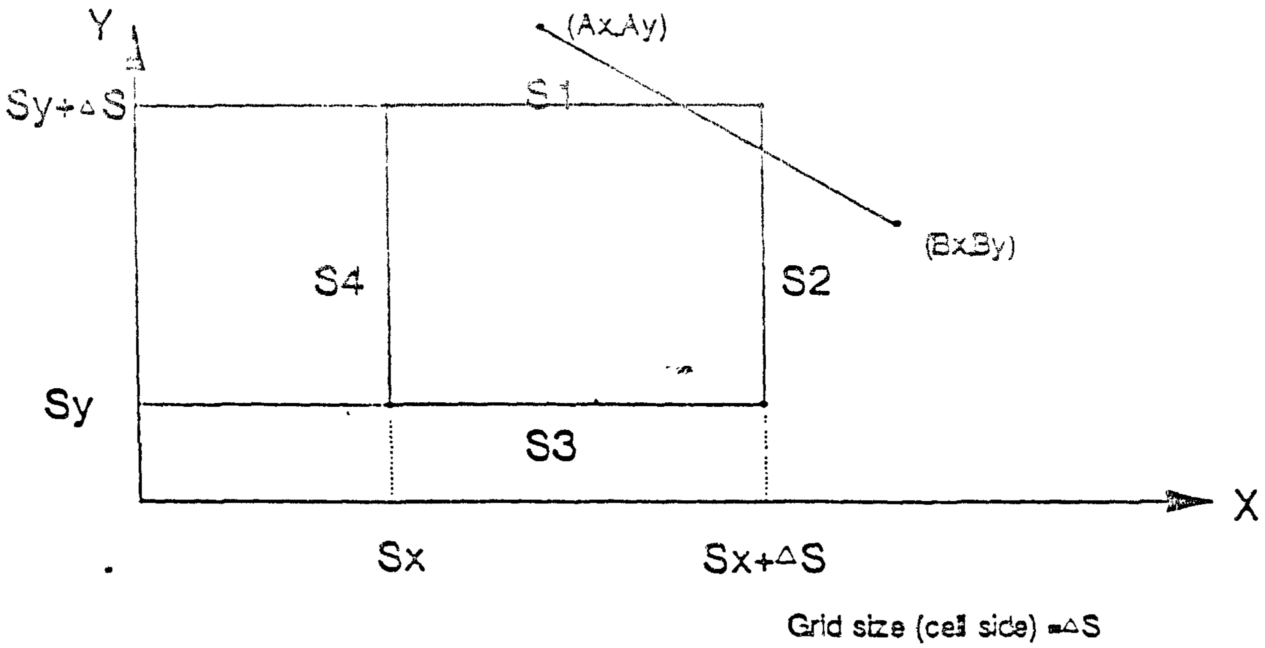


FIGURE 7-1. Depiction of Typical Link and Inventory Grid Cell.[3]

points on the street map must be identified (good reference points are county line intersections) whose coordinates can be determined from a USGS map to enable accurate conversion of the street map locations to the modeling coordinate system.

To facilitate the determination of the links coordinates, it is highly recommended that a electronic digitizer be used to map out the start and end points of each link. A digitizer is an electronic sensor that can translate any position on a digitizer board into numerical coordinates. Thus, any coordinates of a map can be converted into the numerical coordinates of the digitizer by simply attaching the map to a fixed location on a digitizer board and moving the sensor to each link start and end point location. In addition, two reference points are needed for the conversion of the digitizer coordinate system and the coordinate system of the modeling region.

7.5.2 Non-link Mobile Emission Spatial Surrogates

Non-link surrogates are employed for the spatial allocation of mobile emissions for the following situations:

- Links are too numerous to define and process. This is typically the case for on-road rural and urban vehicles and off-road vehicles.

- Emission totals are too insignificant to warrant the development of links; this occurs in some applications for railroad locomotives and vessels.

- Use of land-use based spatial surrogates provides a more accurate allocation of vehicle emissions. Such is the case when vessel transport occurs uniformly over a wide waterway.

The procedure for the allocation of emissions according to land-use data is outlined in Section 6.2.2 and is directly applicable to non-link surrogate situations.

The UAM EPS will use the surrogates shown in Table 7-8 in the absence of link data, and in most UAM applications a combination of link and land-use surrogates are used for the spatial allocation of mobile source emissions. As an example, Figure 7-2 shows the development of links for the Dallas/Fort Worth area. In this figure, 131 links were developed for the allocation of limited access roads and commercial airports. Figure 7-3 shows the gridded mobile inventory from this allocation, using the surrogates indicated in Table 7-6 for those categories for which links were not developed.

TABLE 7-8. Land-use surrogates recommended for spatial allocation of mobile source emissions in the absence of link data.

Mobile Source Category*	Recommended Land-use Surrogate
On-road vehicles (urban)	Urban
On-road vehicles (rural)	Rural
Off-road vehicles (all types)	Rural
Airplanes (civil and military)	County area
Railroad locomotives	Urban
Vessels (all types)	Water

* For on-road vehicles on limited access roadways and commercial aircraft, no surrogates other than links are recommended.

source: Reference 5

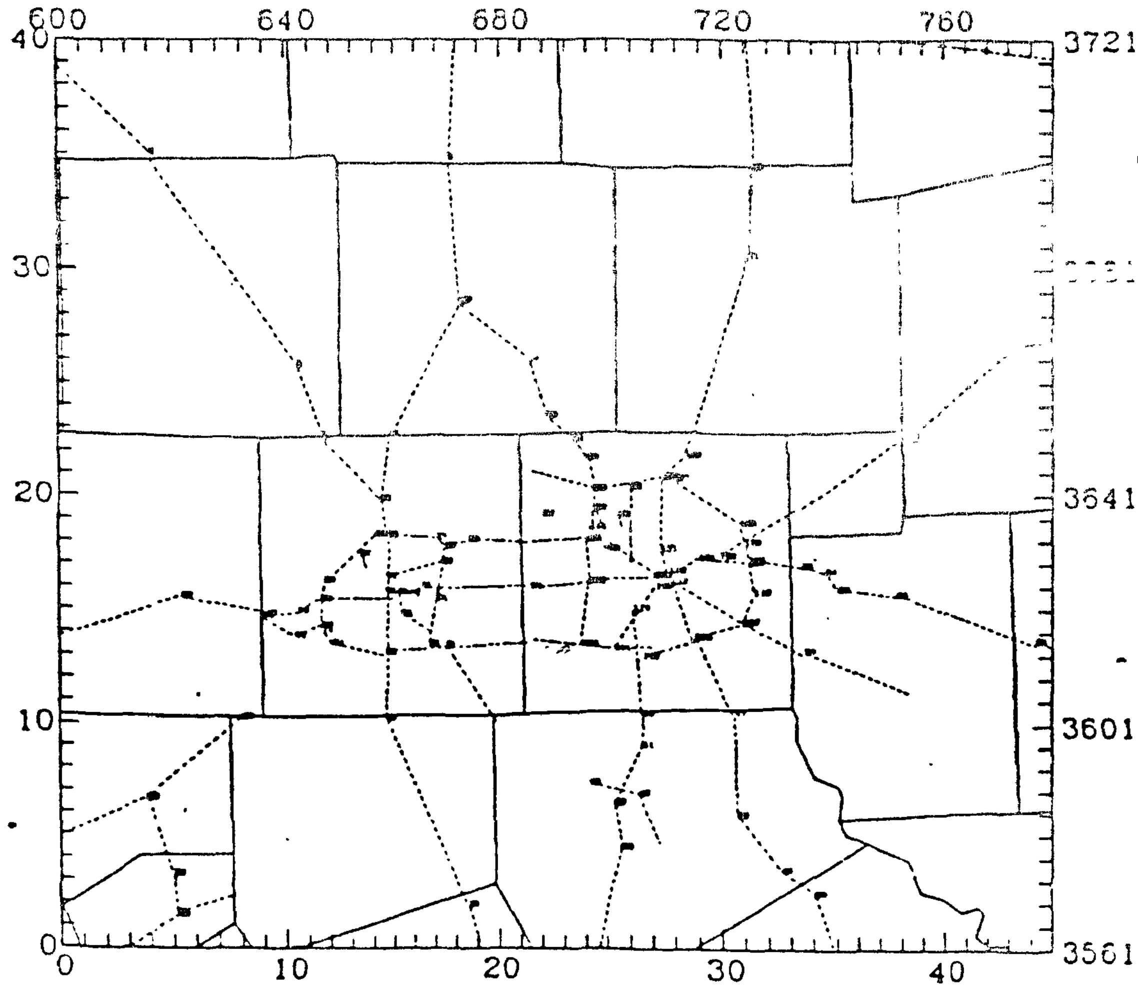


FIGURE 7-2. Mobile source link surrogates developed for a UAM application of the Dallas/Fort Worth region.

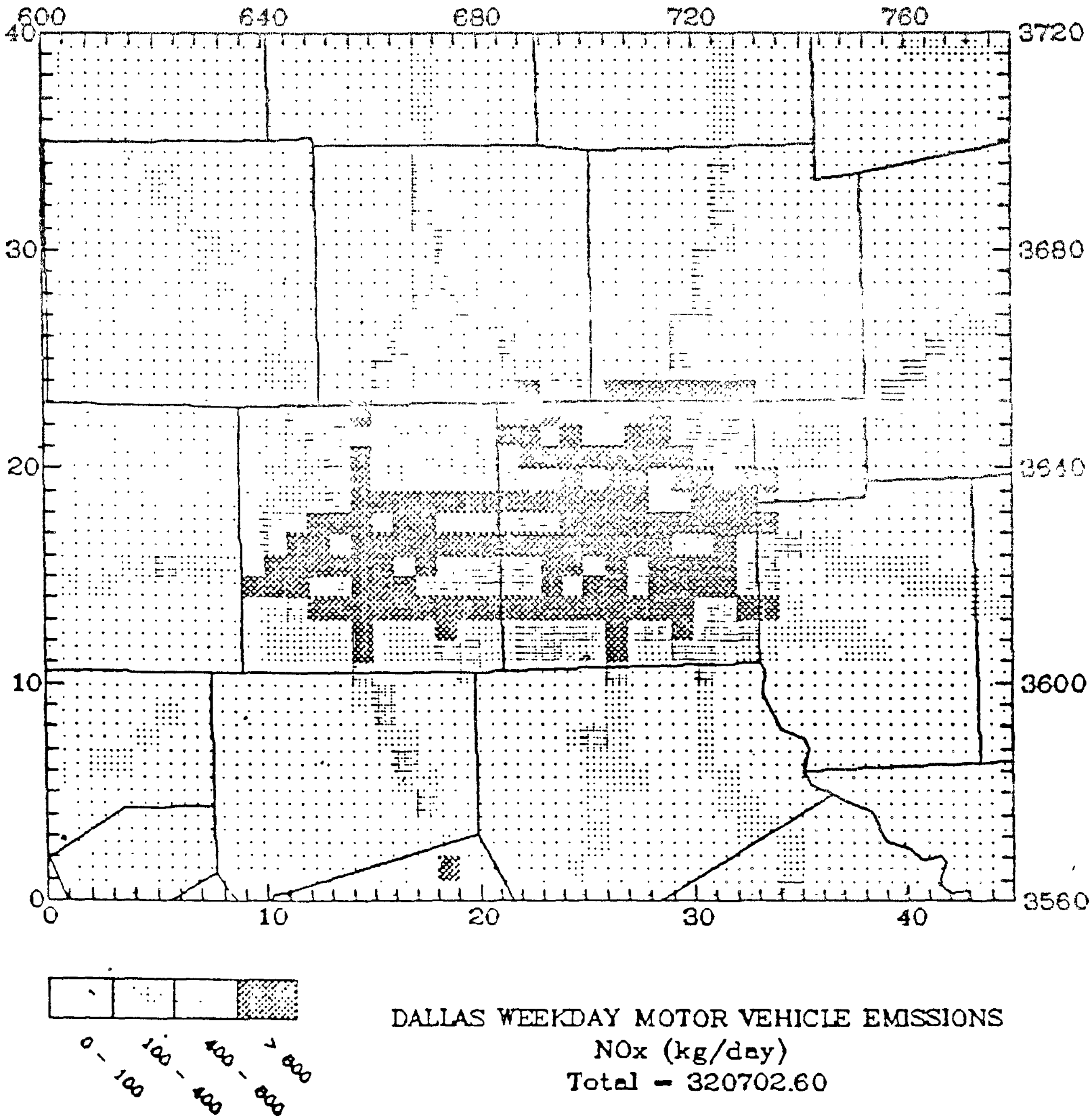


FIGURE 7-3. Gridded annual average mobile source emissions for a UAM application of the Dallas/Fort Worth region.

7.6 TEMPORAL RESOLUTION OF MOBILE SOURCE EMISSIONS

Temporal adjustment of the mobile source inventory into monthly, daily, and hourly specific totals is not significantly different than the treatment of other area source categories. Accordingly, consult Section 6.3 for recommended procedures for temporal adjustment of mobile source emissions. As a special consideration for weekend inventories, note that diurnal variations in weekend driving activity generally differ markedly from weekday patterns (which typically exhibit a "double-peaked" profile, with the most activity occurring during the morning and afternoon commute hours). Accordingly, the emissions modeler should be careful to select a diurnal variation pattern for on-road motor vehicle emissions which is appropriate for the modeling episode. If hourly vehicular speeds and VMT distributions are available from the local Metropolitan Planning Organizations (MPOs), these should be utilized in estimating hourly mobile source emissions.

> The UAM EPS daily and hourly variation codes are shown in Tables 5-4 and 5-5 respectively. In Table 5-4, the default assignment for daily variation of mobile emissions is code #23. In Table 5-5, the default assignment for diurnal variation of all on-road source categories is code #48 for weekends and code #50 for weekdays. It is extremely important in any UAM application to check these values with any locale-specific data to determine their applicability. In addition, the UAM EPS assumes a flat profile for monthly variation of on-road mobile emissions. This is not characteristic of any particular region, but is an indication of the wide variance of monthly factors depending on location. Monthly VMT adjustments should be determined and directly incorporated into the VMT calculations of Section 7.5.

References For Chapter 7

1. Compilation of Air Pollution Emission Factors, Fourth Edition and Supplements, AP-42, U.S. Environmental Protection Agency, September 1985.

2. User's Guide to MOBILE4, EPA-AA-TEB-89-01, U.S. Environmental Protection Agency, February 1989.

3. Procedures for Inventory Preparation, Volume IV: Mobile Sources, EPA-450/4-81-026d (Revised), U.S. Environmental Protection Agency, July 1989.

4. Guidance on Estimating Motor Vehicle Emission Reductions From the Use of Alternative Fuels and Fuel Blends, EPA-AA-TSS-PA-87-4, U.S. Environmental Protection Agency, January 1988.

5. User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System, EPA-450/4-90-007D, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1990.

6. Anthropogenic Emissions Data for the 1985 NAPAP Inventory, EPA 600/7-88-022, Alliance Technologies Corporation, November 1988.

8 BIOGENIC EMISSIONS

8.1 INTRODUCTION

In recent years, air quality modelers have begun to recognize that biogenic emissions (naturally occurring emissions from vegetation) can contribute significantly to the total emission inventory, even in predominantly urban regions. Some of these naturally occurring organic [illegible] are quite photochemically reactive [illegible] the modeling inventory must include some estimate of [illegible] completeness.

In a collaborative effort, researchers at Washington State University and [illegible] developed a computerized system to estimate hourly gridded biogenic emissions. This system, called the Biogenic Emissions Inventory System (BEIS), is available to the public from EPA. Much of the following overview of the BEIS is taken from the paper "Development of a Biogenic Emissions Inventory System for Regional Scale Air Pollution Models"[1] (this paper is reproduced in its entirety in Appendix D of the EPS User's Manual[2]).

8.2 OVERVIEW OF THE BEIS

The BEIS estimates biogenic emissions based on various biomass, emission, and environmental factors. In general, the basic equation for these calculations can be expressed as

$$ER_i = \Sigma_j \, [BF_j \cdot EF_{ij} \cdot F(S,T)] \qquad (8\text{-}1)$$

where ER is the emission rate (in grams/second per model grid cell), i is the chemical species (such as isoprene or monoterpene), j is the vegetation type, BF is the leaf biomass factor (in grams/square meter), EF is the emission factor (in micrograms/gram-leaf biomass/hour), and F(S,T) is an environmental factor accounting for solar radiation (S) and leaf temperature (T).

The BEIS produces one output file: a binary UAM-format low-level emissions file. This file contains hourly gridded biogenic emission rates for olefins, paraffins, isoprene, aldehydes, NO, and NO_2.

8.2.1 Leaf Biomass Factors

The leaf biomass data base used by BEIS was derived from land use data in the Oak Ridge Laboratory's Geoecology Data Base. The land use data base is resolved at the county level and includes acreages for forest types, agricultural crops, and other areas such as urban, grassland, and water. Each of the forest types in the land use data base is assigned to either oak, other deciduous, or coniferous. The leaf biomass for each forest group is partitioned into four emission categories: high isoprene deciduous, low isoprene deciduous, non-isoprene deciduous, and coniferous. Table 8-1 shows the biomass factors for each forest group.

BEIS seasonally adjusts biomass based on the frost [illegible] step function. For each month, deciduous vegetation [illegible] either full biomass or no biomass. Since most high ozone episodes occur during the summer months, this is not usually a critical assumption.

8.2.2 Emission Factors

The emission factors used in BEIS are based largely on Zimmerman's study of biogenic emission rates in the Tampa/St. Petersburg Florida area.[3] These factors for the three forest groups are shown in Table 8-2. Emission factors are given for four hydrocarbon species: isoprene, α-pinene, monoterpene, and unidentified.

The Carbon Bond IV speciations for these four species are shown in Table 8-3 (consult Chapter 9 for a discussion of the Carbon Bond IV mechanism). Multiplying the biogenic emission factors in Table 8-2 by the biomass factors in Table 8-1 results in the emission fluxes shown graphically in Figure 8-1 for each of the vegetation types. Figure 8-2 shows the spatial distribution of standardized biogenic non-methane hydrocarbon emission fluxes for the contiguous United States.

Some natural sources also emit quantities of NO_x; these sources include biomass burning, lightning, microbial activity in soils, and ammonia oxidation. Although these natural sources will generally be much smaller than anthropogenic source emissions in urban regions, concerns about air quality in rural regions with fewer anthropogenic emissions suggests that NO_x emissions from natural sources should be considered in the modeling inventory. Because of the lack of sufficiently detailed emission factors for the other natural source types, the BEIS currently estimates NO_x emissions from grasslands only.

TABLE 8-1. Leaf biomass factors (g/m^2) by forest group.

Forest Group	High isoprene deciduous	Low isoprene deciduous	Non-isoprene deciduous	Non-isoprene coniferous
Oak	185	60	60	70
Other deciduous	60	185	90	135
Coniferous	39	26	26	559

source: Reference 1

TABLE 8-2. Biogenic emission factors ($\mu g/g/h$) for each biomass emission category, standardized for full sunlight and 30°C.

Chemical Species	High isoprene deciduous	Low isoprene deciduous	Non-isoprene deciduous	Non-isoprene coniferous
Isoprene	14.69	6.60	0.00	0.00
α-Pinene	0.13	0.05	0.07	1.13
Monoterpene	0.11	0.05	0.07	1.29
Unidentified	3.24	1.76	1.91	1.38

source: Reference 1

TABLE 8-3. Carbon Bond IV speciation for BEIS biogenic species (moles CB-IV species/mole chemical species).

	Carbon Bond Species				
Chemical Species	OLE	PAR	ALD2	ISOP	Non-Reactive
Isoprene	-	-	-	1	-
α-Pinene	0.5	6	1.5	-	-
Monoterpene	0.5	6	1.5	-	-
Unidentified	0.5	8.5	-	-	0.5

source: Reference 1

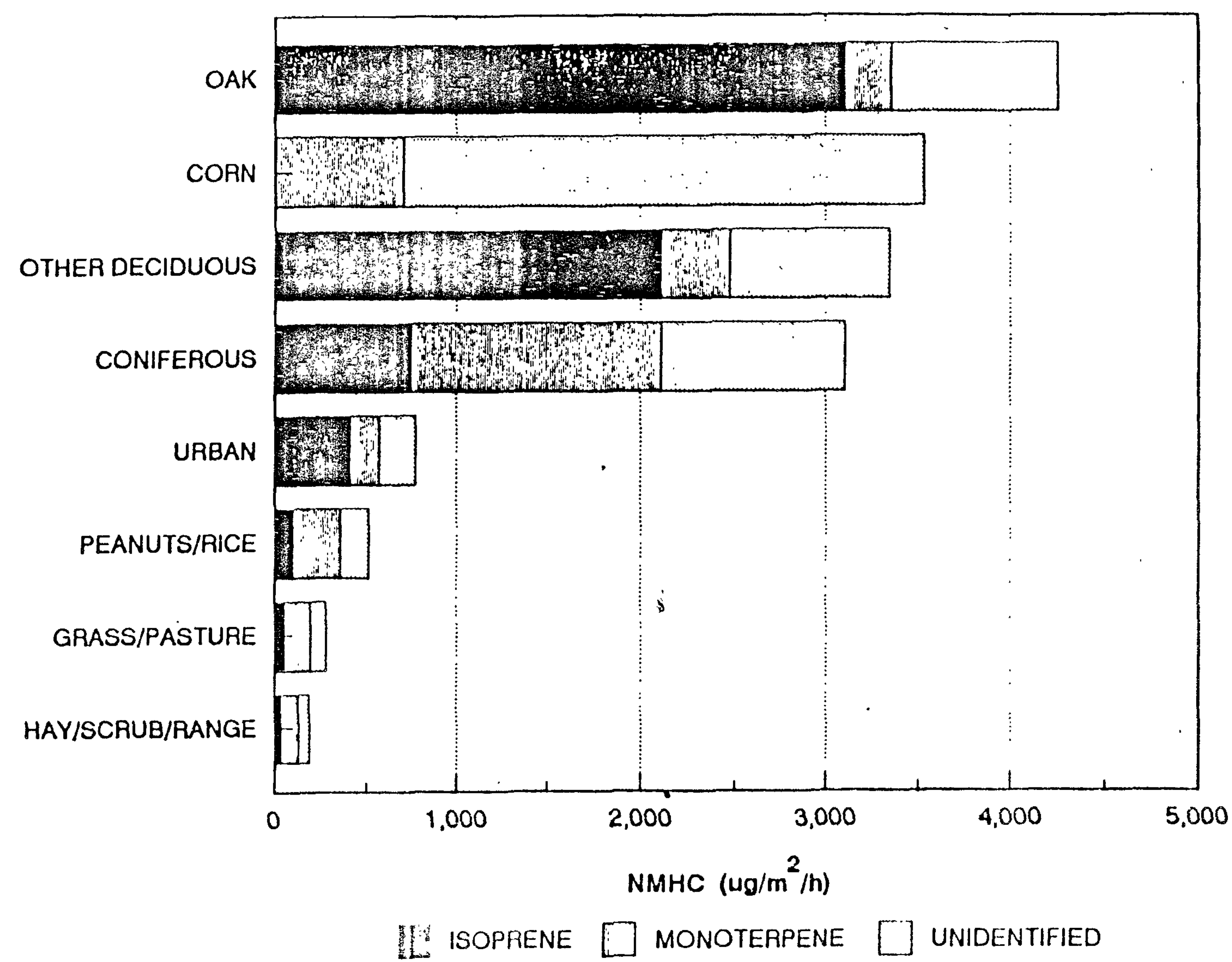


FIGURE 8-1. Non-methane hydrocarbon fluxes by vegetation type.[1]

90098 08'1

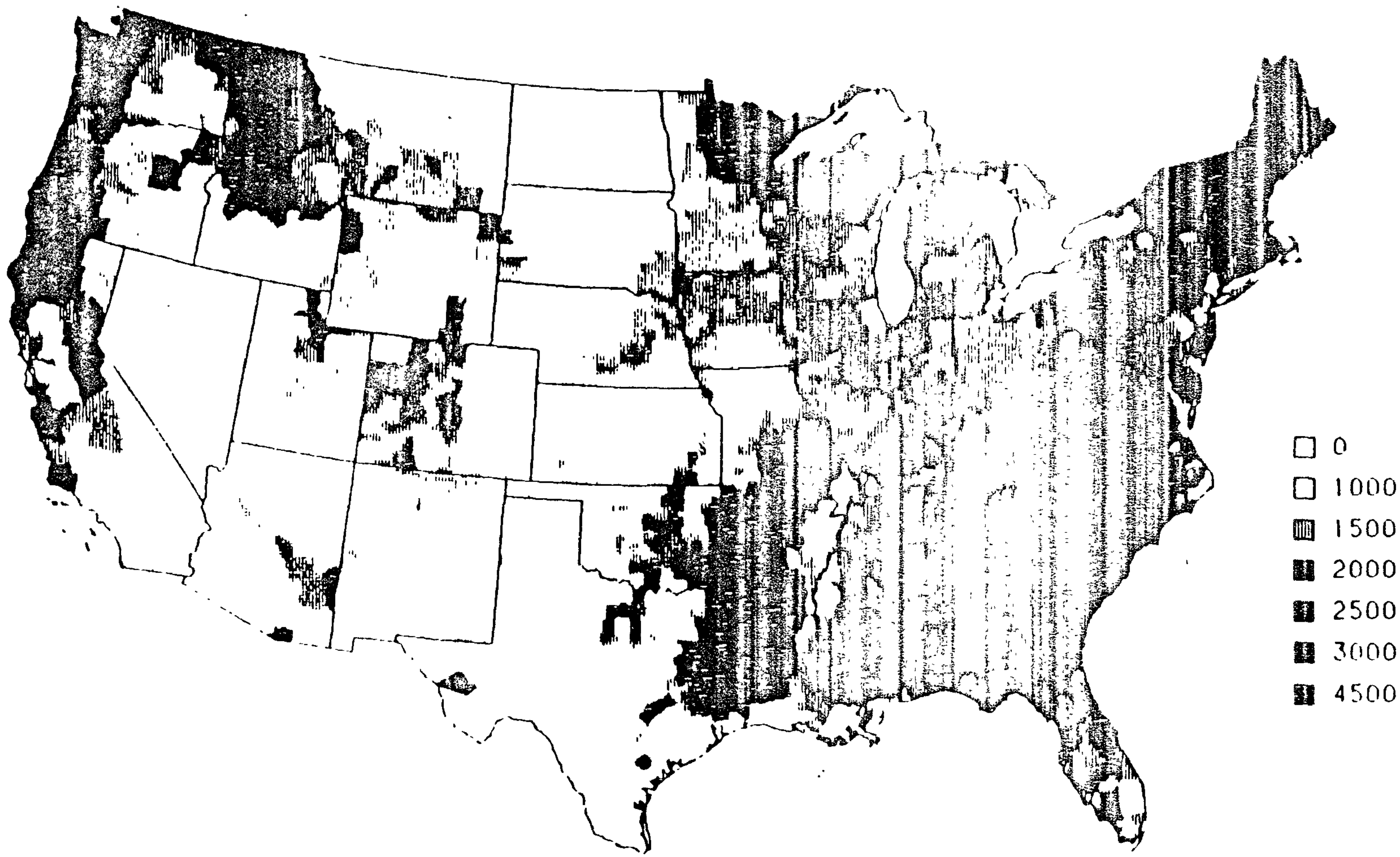


FIGURE 8-2. Standardized biogenic NMHC fluxes (assuming 30°C and bright sunlight). Units are in micrograms per square meter per hour.[1]

90098 08

8.2.3 Environmental Factors

Studies indicate that biogenic emissions from most plant species are strongly temperature-dependent; isoprene emissions also vary with solar intensity. The emission factors used by BEIS are standardized for full sunlight and 30° Celsius. The BEIS adjusts these emission factors to account for the effects of variations in ambient conditions using relationships derived by Tingey.[4,5,6] The emission factor sensitivities to leaf temperature for isoprene and monoterpene are shown graphically in Figure 8-3.

BEIS also simulates the vertical variation of leaf temperature and sunlight within the forest canopy. The canopy model employed by BEIS assumes that sunlight decreases exponentially through the hypothetical forest canopy; the rate of attenuation depends on the assumed biomass distribution. Figure 8-4 shows a schematic representation of the assumed canopy types for deciduous and coniferous forest groups. Visible and total solar radiation are calculated for eight levels in the canopy and used to compute the leaf temperature at each level; Figure 8-5 presents the assumed temperature and solar flux variation by canopy layer for deciduous and coniferous forests.

8.3 INPUT REQUIREMENTS OF THE BEIS

The BEIS uses three types of data files: UAM preprocessor data, user-supplied data, and data supplied to the user by EPA. Figure 8-6 shows a flow chart of the BEIS flow of information. Each of the input data files is briefly described below. Appendix D of the User's Guide for the Urban Airshed Model: Volume IV: User's Guide for the Emissions Preprocessor System[2] contains detailed format descriptions of the various input files.

UAM Preprocessor Data. Two of the UAM preprocessor files are also used by BEIS. The first is the WDBIN file, produced by the UAM winds preprocessor and containing hourly, gridded surface wind speed data. The second file is the TPBIN file, which is produced by the UAM temperature preprocessor program. This file contains hourly, gridded temperature data. These files should be available from the photochemical modeler.

User-Supplied Data. The user must supply two types of data: meteorological and county allocation data. The meteorological data consists of surface meteorology information on relative humidity, cloud coverage, and cloud height for one station within the particular UAM domain. The county allocation data is comprised of records containing the percent of a given county that is in a given grid cell.

EPA-Supplied Data. The EPA provides two data files for use with the BEIS. The first of these files is a leaf biomass distribution data base. This file contains, at a county level, the following data for the contiguous United States: (1) hectare values for canopy, non-canopy, and urban tree areas; and (2) canopy biomass density (kg/ha) for oaks species,

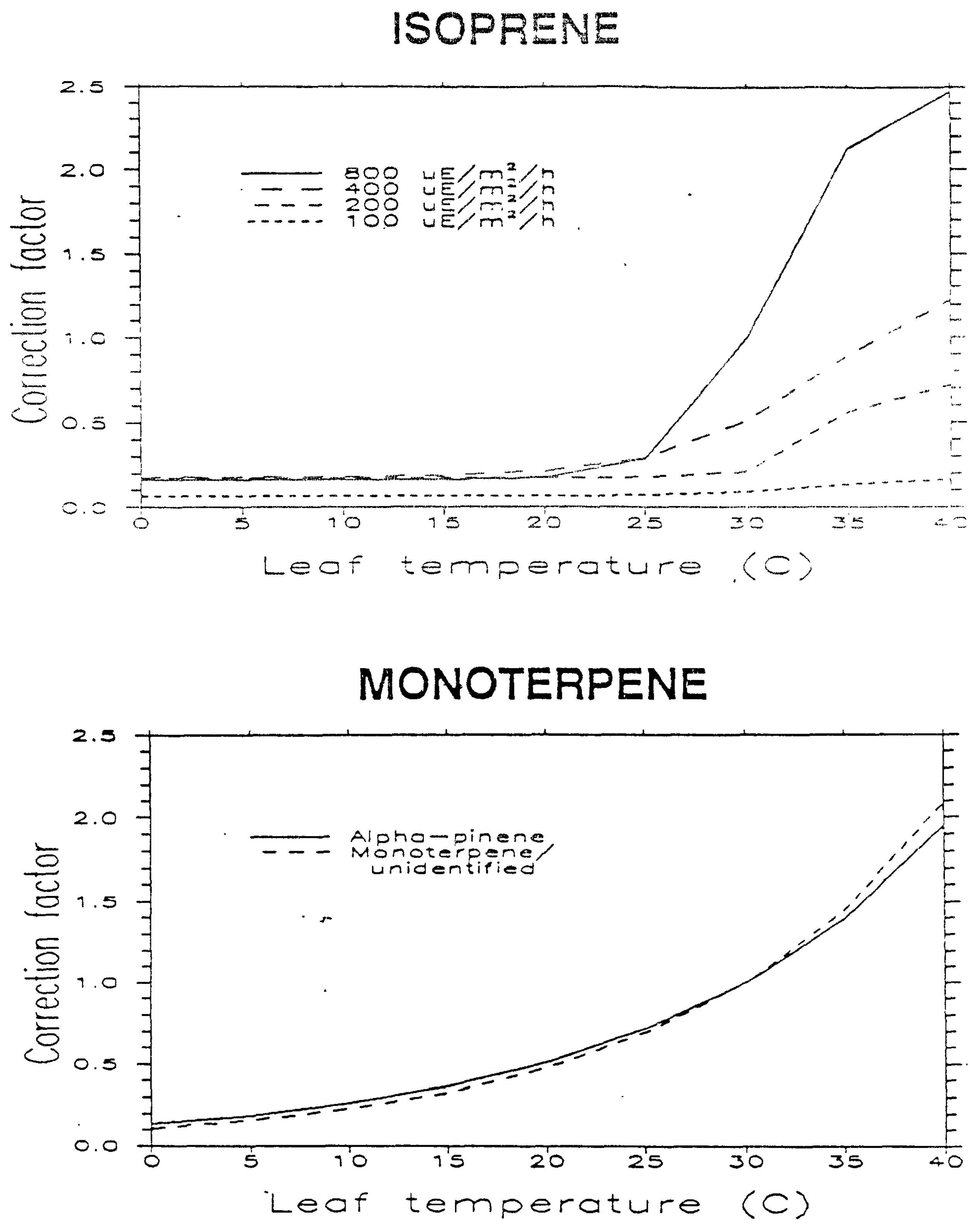


FIGURE 8-3. Emission factor sensitivity to leaf temperature.

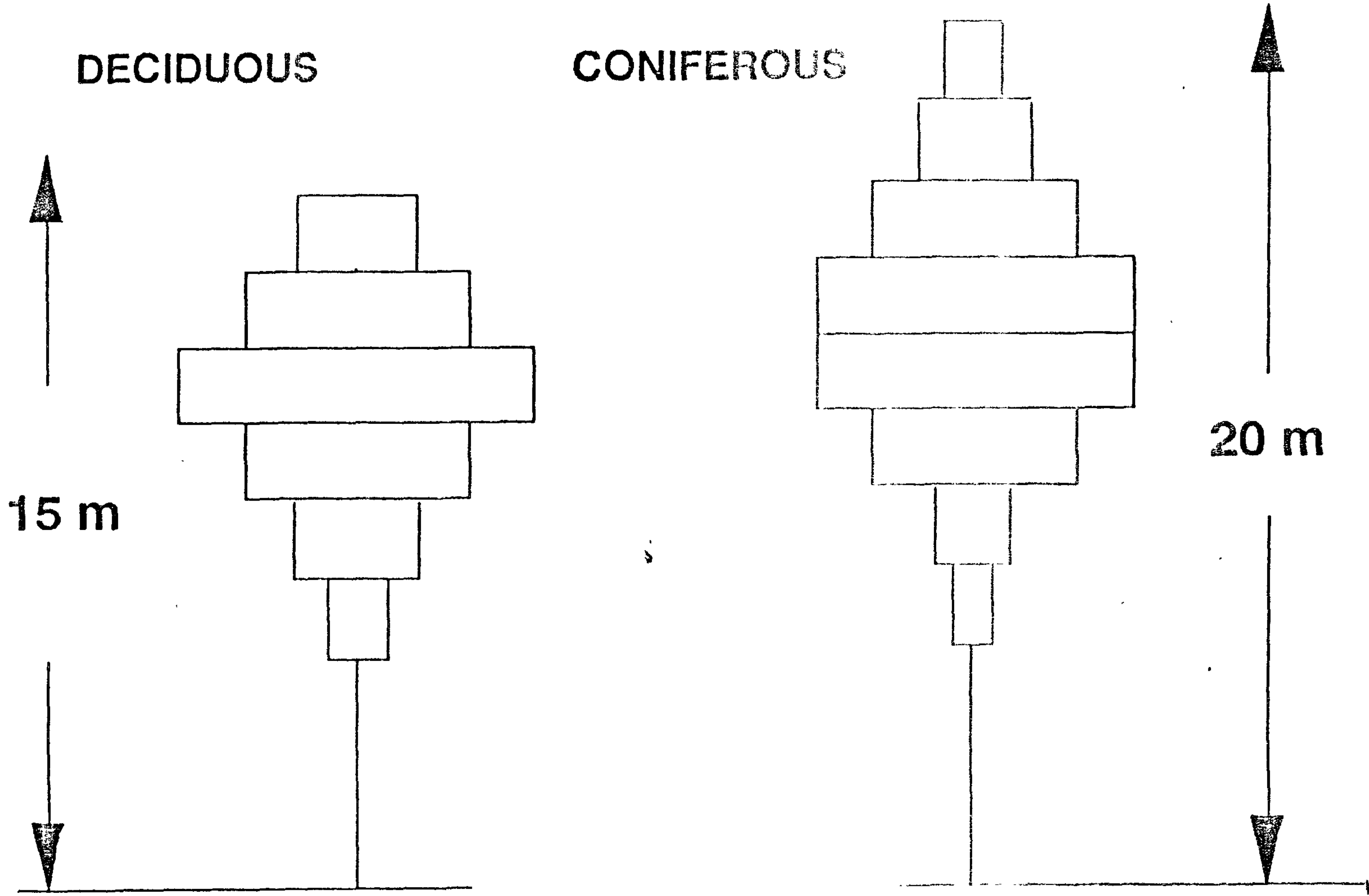


FIGURE 8-4. Schematic representation of forest canopy type

90098 08'1

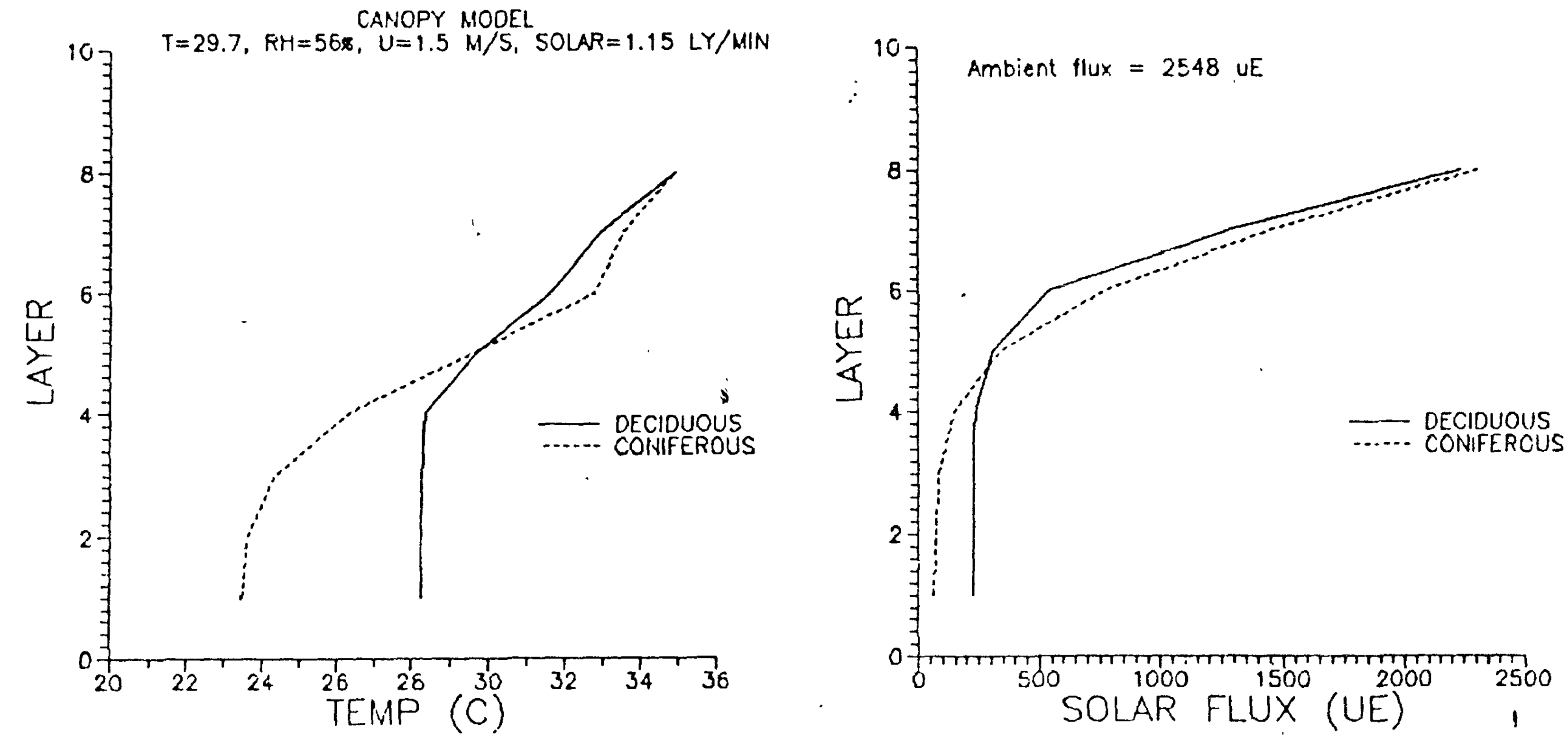


FIGURE 8-5. Temperature and solar flux variations by canopy layer.

90098 08'

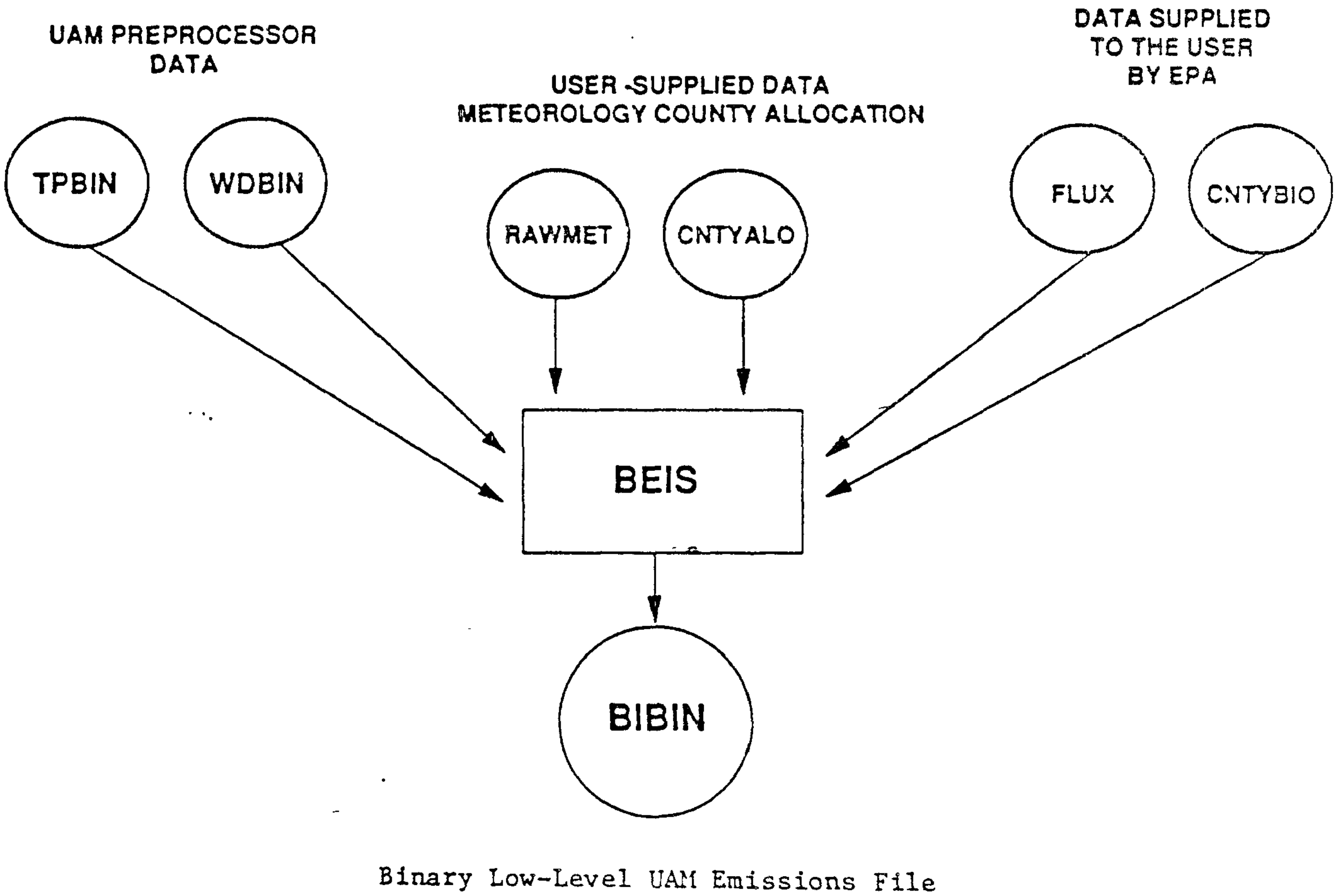


FIGURE 8-6. UAM stand-alone biogenics processor. Overview of the Biogenic Emission Inventory System (BEIS).

other deciduous species, and coniferous species, by month. The second data file consists of actinic (spherically integrated) flux data. This data is provided for ten zenith angles for different wavelengths of the solar spectrum, ranging from 290 nm (ultraviolet) to 800 nm (near infrared) in increments of 10 nm.

8.4 USER-SPECIFIED LAND USE DATA

One of the major limitations of the BEIS as it is currently implemented is the lack of subcounty spatial resolution in the land use data base used to grid biogenic emissions. (Note, however, that the final model-compatible emissions file produced by BEIS may show spatial variations in emissions at a subcounty level because the BEIS uses gridded relative humidity and temperature data in its environmental factor correction algorithms.) Two upcoming modifications to the BEIS, scheduled for completion by May 1991, will rectify this limitation, however; these modifications are [illegible]

(1) The BEIS source code will be modified to allow the user to easily update land use data on a county basis using existing land use categories for both canopy and non-canopy (i.e., crop) data.

(2) An option will be added to allow the user to use gridded land use data in the BEIS, utilizing the current land use categories.

8.5 PROJECTION OF BIOGENIC INVENTORIES

In general, the same emissions factors will be used to estimate biogenic emissions for both base and projection years. However, the agency may wish to incorporate the effects of anticipated changes in land use patterns on spatial allocation of biogenic emissions into the projection inventories if this type of data is available. Changes in land use may also affect the amount of biogenic emissions contained in the modeling inventory, since the acreage of forest or agricultural land in each grid cell is used to estimate the biogenic emissions for that cell.

- One case where land use patterns might be expected to change dramatically, thus affecting the amount and spatial allocation of biogenic emissions, would be if major land development projects (such as new housing developments or industrial parks) are planned. Consult local planning agencies to determine if this situation exists.

For most applications, however, the assumption that biogenic emissions will remain constant between the base and projection years will not be a significant source of error.

References for Chapter 8

1. Development of a Biogenic Emissions Inventory System for Regional Scale Air Pollution Models, T. E. Pierce, B. K. Lamb, and A. R. Van Meter, Paper No. 90-94.3, presented at the 83rd Air and Waste Management Association Annual Meeting at Pittsburgh, Pennsylvania, June 1990.

2. User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System, EPA-450/4-90-007D, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1990.

3. P. Zimmerman, Determination of Emission Rates of Hydrocarbons from Indigenous Species of Vegetation in the Tampa Bay/Petersburg, Florida Area, EPA-904/9-77-028, U.S. Environmental Protection Agency, Atlanta, GA, 1979.

4. D. Tingey, Atmospheric Biogenic Hydrocarbons, J. Bufalini and R. Arnts, eds., Ann Arbor Science Publication, Ann Arbor, MI, 1981, pp. 53-79.

5. D. Tingey, R. Evans, and M. Gumpertz, "Effects of Environmental Conditions on Isoprene Emissions from Live Oak," Planta (152): 565 (1981).

6. D. Tingey, M. Manning, L. Grothaus et al., "Influence of Light and Temperature on Monoterpene Emission Rates from Slash Pine," Plant Physiol. (65): 797 (1980).

9 SPECIATION OF VOC AND NO_x EMISSIONS INTO CHEMICAL CLASSES

9.1 INTRODUCTION

Most photochemical models, including the UAM, require that VOC emissions be expressed in terms of designated groups or "classes" of compounds. Additionally, in some models, [illegible] may have to be specified as NO and NO_2. Each model's classification requirements differ somewhat; this chapter focuses on speciation of emissions according to the Carbon Bond IV Mechanism employed by the UAM.

9.2 THE CARBON BOND-IV MECHANISM

The currently available version of the UAM uses version IV of the Carbon Bond Mechanism (CB-IV). Since every reaction of all of the organic species found in an urban atmosphere cannot be considered, these pollutants must be grouped to limit the number of reactions and species to a manageable level while permitting reasonable accuracy in predicting ozone formation. Each carbon atom of an organic molecule is classified according to its bond type. As implemented in the UAM, the CB-IV contains over 80 reactions and more than 30 species. These reactions and species are tabulated in Appendix A of the <u>User's Guide for the Urban Airshed Manual, Volume I</u>.[1]

The differential equations that describe the CB-IV contain wide variations in time (reaction rate) constants. The UAM uses quasi-steady-state assumptions for the low-mass, fast-reacting species and a more computationally efficient algorithm for the remainder of the state species. Table 9-1 lists the carbon bond species used in the CB-IV version of the UAM.

In the UAM EPS, each carbon atom of total VOC emissions is assigned to one of the following ten species listed in Table 9-1: olefinic carbon bond (OLE), paraffinic carbon bonds (PAR), toluene (TOL), xylene (XYL), formaldehyde (FORM), high molecular weight aldehydes (ALD2), ethene (ETH), methanol (MEOH), ethanol (ETOH), and isoprene (ISOP). NO_x emissions are partitioned into NO and NO_2. Emissions of CO can also be included in the UAM modeling inventory.

TABLE 9-1. Definition of the UAM (CB-IV) species.

UAM Species	Species Name
NO	Nitric oxide
NO2	Nitrogen dioxide
O3	Ozone
OLE	Olefinic carbon bond (C=C)
PAR	Paraffinic carbon bond (C-C)
TOL	Toluene (C_6H_5-CH_3)
XYL	Xylene (C_6H_8-$(CH_3)_2$)
FORM	Formaldehyde ($CH_2=O$)
ALD2	High molecular weight aldehydes (RCHO, R>H)
ETH	Ethene ($CH_2=CH_2$)
CRES	Cresol and higher molecular weight phenols
MGLY	Methyl glyoxal ($CH_3C(O)C(O)H$)
OPEN	Aromatic ring fragment acid
PNA	Peroxynitric acid (HO_2NO_2)
NXOY	Total of nitrogen compounds ($NO + NO_2 + N_2O_5 + NO_3$)
PAN	Peroxyacyl nitrate ($CH_3C(O)O_2NO_2$)
CO	Carbon monoxide
HONO	Nitrous acid
H2O2	Hydrogen peroxide
HNO3	Nitric acid
MEOH	Methanol (optional)
ETOH	Ethanol (optional)
ISOP	Isoprene

source: Reference 1

9.3 CHEMICAL ALLOCATION OF VOC

Generally, the basic annual inventory will contain estimates of either total VOC or non-methane VOC, depending on what emission factor information is used for computing emissions. The basic approach for allocating VOC into the classes needed by a photochemical model is to employ a set of "split factors" that distribute a certain fraction of the VOC total into each class. A simple example demonstrates this concept:

- Assume a source emits 10 tons of VOC per day; the split factors for this particular source are 0.2 tons OLE/ton VOC, 0.5 tons PAR/ton VOC, and 0.3 tons ALD2/ton VOC. Simple multiplication of each factor by the total tonnage of VOC yields the quantity of VOC in each carbon [illegible] 5, and 3 tons per day, respectively.

This allocation step would, of course, have to be performed for each emitter [illegible] developed in the inventory using different split factors appropriate for each source or source category. Please note that the example above is simplified; the UAM requires that split factors be provided in terms of moles CB-IV species per gram total VOC. Calculation of split factors in these units will be discussed further below.

As can be seen from the above example, the VOC allocation step is not difficult once the split factors are available for each source. The major difficulty in this process is determining which split factors are most appropriate. Two basic approaches can be followed for determining split factors. Ideally, VOC split factors should be source-specific, reflecting the actual composition of VOC emissions from each individual source.

- For example, because of the importance of gasoline evaporation in VOC inventories, local gasoline composition data should be obtained corresponding to the summer season in the modeling area (note that liquid composition data would have to be adjusted to best reflect vapor composition). Additionally, source tests could be performed to determine VOC species data for each major facility in the region (refineries, chemical manufacturers, etc.), and solvent composition data could be solicited from smaller commercial and industrial establishments (dry cleaners, degreasers, etc).

From this type of information, a photochemical modeling specialist could determine appropriate split factors for each source. See Appendix B for additional guidance on construction of source-specific speciation split factors.

Because of resource limitations and unavailability of solvent composition data, however, collecting source specific speciation data is generally impractical for all but a very few large point or area source emitters. An alternative method employs generalized VOC speciation data from the literature to develop VOC split factors by source type. To develop CB-IV split factors from generalized speciation data, the individual chemical compounds typically present in the emissions from each source type (and their molecular weights and weight fractions of the emissions mixture) must first be identified. Then, each of the chemical compounds present in the modeling inventory must be classified according to the CB-IV mechanism.

Table 9-2 contains a sample EPA VOC speciation profile; this particular profile provides an estimate of the composition of VOC emissions resulting from storage of petroleum products in fixed roof tanks. This table is taken from the Air Emissions Species Manual, Volume 1: Volatile Organic Compound Species Profiles.[2] The Air Emissions Species Manual contains over 250 "emission profiles" like the example in Table 9-2 for various point and area source categories; the manual also contains profiles for [illegible] motor vehicles and aircraft. In each profile, individual chemical compounds [illegible] their corresponding molecular weights and weight percentage of the mixture. (The EPA speciation profile codes and descriptions are listed in Appendix A).

The type of information contained in Table 9-2 can be used with the CB-IV [illegible] assignments for individual chemical compounds from Guidelines for Using OZIPM-4 with CBM-IV or Optional Mechanisms[3] to calculate composite split factors by speciation profile. For each profile, the weight percentages associated with each organic compound are summed for each carbon bond classification and the average molecular weight of the mixture computed. The split factors are expressed in units of (moles of carbon bond species)/(gram total VOC) and represent a weighted composite of the carbon bond class assignments for each of the chemical compounds present in the mixture. Mathematically, this can be expressed as

$$\text{for each } i,\ \Sigma_j\ [(WF_j\ /\ MW_j)\ \cdot\ (\text{moles of } i\ /\ \text{mole } j)] \qquad (9\text{-}1)$$

where i is the CB-IV species, j is each chemical compound in the mixture (e.g., carbon tetrachloride), WF_j is the weight fraction of j in the mixture, and MW_j is the molecular weight of chemical compound j.

If source-specific data is unavailable, the emissions modeler can use the speciation profiles contained in the Air Emissions Species Manual (with the CB-IV species assignments for individual chemical compounds) to generate appropriate split factors by source type in the manner described above. Whenever possible, however, speciation profiles should be reviewed to ensure local applicability, especially for the major point sources and important area sources in the modeling region.

The split factors file provided with the UAM EPS contains CB-IV split factors (in units of moles of CB-IV species/gram total VOC) for each of the profiles listed in Appendix A. In addition to the split factors for the ten VOC carbon bond

TABLE 9-2. Example VOC speciation profile from the Air Emissions Species Manual (EPA, 1988).

Profile Name:	Fixed Roof Tank 0 Crude Oil Production
Profile Number:	0296
Control Device:	Uncontrolled
Data Source:	Engineering evaluation of test data and literature data

SAROAD Number	CAS Number	Species Name	Mol. Weight	Percent Weight
43115		C-7 Cycloparaffins	98.19	1.30
43116		C-8 Cycloparaffins	112.23	0.50
43122		Isomers of Pentane	72.15	1.50
43201	74-48-8	Methane	16.04	6.20
43202	74-48-0	Ethane	30.07	5.60
43204	74-49-6	Propane	44.09	17.60
43212	106-69-8	N-Butane	58.12	27.10
43214	75-52-5	Iso-Butane	58.12	1.50
43220	109-96-0	N-Pentane	72.15	14.60
43231	110-05-3	Hexane	86.17	7.90
43232	142-82-5	Heptane	100.20	9.20
43233	111-16-9	Octane	114.23	6.90
45201	71-14-2	Benzene	78.11	0.10
			SUM TOTAL	100.00

source: Reference 2

> classes used in EPS, this file contains factors to split out the non-reactive portion of VOC and disaggregate NO_x emissions into NO and NO_2. These split factors were calculated on a basis of total VOC; if the inventory contains estimates of reactive VOC, the split factors for each profile must be renormalized by removing the non-reactive portion. Section 9.6 of this chapter addresses conversion of split factors to be compatible with the inventory.
>
> The speciation profile file, one of the inputs to the EPS program CENTEMS, assigns profile codes based on Source Classification Code (SCC) for point sources and area source category (ASC) code for area and mobile sources. Emissions from sources with SCCs or ASCs not listed in the speciation profile file are assigned to CB-IV species using the overall average speciation profile (EPA speciation profile code 0). The default source category/speciation profile pairings in this file should always be reviewed for appropriateness for the modeling region.

Whether or not the agency intends to employ a model that incorporates the carbon bond mechanism, a photochemical modeling specialist should be consulted to review all procedures, algorithms, and VOC species/split factor data prior to initiating any data collection or allocation effort. The modeling specialist can also provide valuable advice on how to deal with other types of VOCs. In no case should the agency develop split factors or carry out such an allocation without knowing what photochemical model will be run or what classification scheme is needed to meet the model's reactivity requirements.

9.4 SPECIFICATION OF NO_X AS NO AND NO_2

Some photochemical models do not require that nitrogen oxides be distinguished as either nitric oxide or nitrogen dioxide. Instead, these models assume that all NO_x is NO, which is the predominant form of NO_x emitted from combustion processes (the primary source of NO_x emissions).

For models (such as the UAM) that do require this split to be made, however, split factors are applied in the same manner as are VOC split factors. That is, for each source or source category emitting NO_x, two percentages (totaling 100 percent) need to be defined: one corresponding to the fraction of NO_x emitted as NO and the other corresponding to the fraction emitted as NO_2. In this sense, allocating NO_x into NO and NO_2 is analogous to utilizing a 2-class scheme for allocating VOC.

The mode of expression of the necessary split factors may vary from one model to another. NO_x emissions are ordinarily expressed "as NO_2", which means that a molecular weight of 46 is attributed to NO as well as NO_2, even though the true molecular weight of NO is 30. Many models, including UAM, take account of this convention by accepting split factors totaling 100 percent for NO_x "as NO_2", but some may require NO emissions to be expressed in terms of the true weight of NO. The true value for NO is 30/46 or 0.65 times the conventional value of NO "as NO_2." If the inventory maintains NO totals as NO, then care should be taken that a molecular weight of 30 is used when computing moles of NO for use in the photochemical model. It is important, during the planning stages, to review the annual inventory to determine how NO_x is reported and to consult with a modeling specialist to find out how the photochemical model accepts NO_x emissions data.

- Consider a power plant that emits NO_x equivalent to 1,000 kg of NO_2 per hour. Given split factors of 95 and 5 percent by weight "as NO_2", then NO and NO_2 emissions would be equivalent to 950 and 50 kg "as NO_2" per hour, respectively; however, the actual emissions of NO would be only 30/46 of 950, or 620 kg per hour.

At present, few references are available that define split factors for allocating NO_x into NO and NO_2. Two sources of such data are References 4 and 5. As a rough average, 97 percent (by weight as NO_2) of the NO_x emitted from most boilers will be NO.

The CB-IV splits factor file provided with the UAM EPS assumes default splits for NO_x emissions from all source types of 90% and 10% by weight of NO (as NO_2) and NO_2, respectively. The actual values contained in the splits factor file are determined as follows:

NO: (0.90) x [(30 grams NO/mole) / (46 grams NO_x/mole)]
= 0.59 grams NO / gram NO_x

NO_2: (0.10) x [(46 gram NO_2/mole) / (46 grams NO_x/mole)]
= 0.10 grams NO_2 / gram NO_x

9.5 PROJECTION OF VOC AND NO_X SPLIT FACTORS

Just as the quantity of emissions may change in an area from the base year to any projection year, the composition of these emissions may change, as well. To reflect this, different VOC and NO_x split factors may need to be used for each projection year, at least for important sources for which such projected compositional changes can be estimated. One source for which this may be an important consideration is motor vehicles. Changes in emissions control technology and use of alternative or reformulated fuels may result in significantly different VOC split factors for these sources in projection years; emissions modelers should consult EPA for the latest guidance. Similarly, if significant changes are expected in the compositions of petroleum products transported and stored in the modeling area, such changes should be reflected in the projection year split factors. Of course, for many sources, no changes in emission composition will be expected. For instance, no change would be needed for any sources that will use the same solvents in the base year and projection years (e.g., dry cleaners using perchloroethylene). Likewise, since no evidence suggests that NO/NO_2 ratios in combustion emissions will change in the near future, the same NO_x split factors could also be used in projection years.

In any case, different split factors for the base and projection inventories should only be used to reflect anticipated changes in the composition of future emissions. Any other changes in the split factors used for the base and projection inventories may cause the photochemical model to predict changes in ozone concentrations that are due simply to differences in methodology and are unrelated to expected real effects of composition changes.

9.6 COMPATIBILITY WITH INVENTORY DATA AND SOURCE CATEGORIES

Two major types of compatibility with the emissions inventory need to be considered when determining appropriate split factors. First, the split factors must be calculated in units compatible with those used to express VOC totals in the basic inventory. Ordinarily, this means they should be given in terms of total VOC, including methane and any other organic compounds considered unreactive, if such compounds are present in the emissions for the category under consideration. However, if the basic inventory has been compiled in terms of non-methane hydrocarbons (NMHC) or reactive volatile organic compounds (RVOC), the split factors should be given in terms of these totals rather than of total VOC.

> The split factors provided with the UAM EPS are applicable to emissions given as total VOC (including methane). These splits were tabulated on a total VOC basis so as to be compatible with the EPA VOC speciation profiles, which include methane. If they were to be applied (erroneously) to NMHC emissions estimates, the resulting emission estimates in each VOC class would be underestimated since a specified nonreactive fraction of the emissions would be subtracted before allocation of the reactive portion to carbon bond classes.
>
> In this case, the given split factors would have to be adjusted to make them applicable to non-methane VOC emissions. This can be readily accomplished by recalculating the average molecular weight of the mixture without methane; the methane-free molecular weight is then used with the CB-IV species

assignments by chemical compound to generate non-methane VOC split factors using the method described in Section 9-3.

If the existing inventory is not in terms of VOC or non-methane VOC, and instead is divided into some sort of classification scheme that is incompatible with the chemistry employed by the photochemical model, it is questionable whether such an inventory will be useful as input to the photochemical model. Consult a photochemical modeling specialist if this situation exists.

Another important consideration is compatibility of the split factors with the source classification scheme. The source categories and subcategories chosen for the basic inventory may fail to distinguish between sources having substantially different emission compositions, requiring different sets of solit factors. There are several possible solutions to this problem, as shown in the example below.

- Area source degreasing may be considered as a single category in the emission inventory, but different degreasing solvents are used in different plants.

  First, any individual plants which emit significant amounts of solvent vapors from degreasing operations can be treated as point sources, in which case the solvents used at each should be identified and entered in the point source inventory.

  Second, if there are many degreasing operations, each of which emits only relatively small amounts of solvent vapors, it may be possible to determine from solvent suppliers how much of each solvent is used in the region. Lacking any information to the contrary, the agency may then assume that the emissions of each solvent are uniformly spread throughout the grid cells containing degreasing emissions. In this case, degreasing can be treated as a single area source category, with a composite set of split factors reflecting the proportions used of each solvent; alternatively, it can be subdivided into several area source categories, one for each solvent, with the emission totals as determined from the suppliers (Appendix B describes various methods for incorporation of additional source categories into the modeling inventory).

  Third, if there is no locally available information, state or national supply statistics can be used to provide estimates of the subcategory totals, to be used in the manner previously explained.

A similar situation may be encountered in dealing with motor vehicle emissions; different speciation profiles are available for exhaust and evaporative VOC emissions, whereas the basic inventory may only provide a single lumped estimate combining these emission components. Since mobile sources comprise a significant portion of the anthropogenic inventory in most urban areas, these emissions should be recalculated in terms of the two subcategories and the appropriate split factors applied for each category. This enhances the accuracy of the VOC allocation process and facilitates the use of the model to evaluate control strategies that may affect exhaust and evaporative emissions differently.

> **If the emissions modeler is using the UAM EPS to assist modeling inventory development, emissions from on-road motor vehicles will have been disaggregated into exhaust and evaporative (consisting of diurnal, refueling, and running loss components) by the PREGRD program.**

As a special consideration when speciating emissions from on-road motor vehicles, the effects of RVP, oxygenated fuel blends, and alternative fuel use on VOC speciation must also be quantified. Specific guidance on the evaluation of these effects is provided in the EPA Technical Memorandum Motor Vehicle VOC Speciation for SIP Development.[d]

Sometimes, compositional information will simply be unavailable in sufficient detail to permit determination of split factors for many recognized VOC sources. For instance, a petroleum refinery may be represented in the inventory by a large number of point sources (having, for example, different NEDS source classification codes) while only a single set of split factors is available for the entire point source category.

For less significant VOC sources, such as area source fuel combustion, the need for accuracy in assigning split factors becomes correspondingly less important, since moderate errors in these small contributions will result in only very small errors in the individual VOC class totals. A single set of split factors is, therefore, adequate for all external combustion sources operating on a given type of fuel, and no subcategories would be necessary or useful in this case.

In general, the source category list should be reviewed during the early stages of the planning effort to ensure that all subcategories essential for proper allocation of emissions to VOC classes have been recognized and established for data collection. This is especially important if special surveys or questionnaires are to be utilized, because failure to retrieve all the necessary information in the initial contact can seriously impair the productivity of the effort.

9.7 DATA HANDLING CONSIDERATIONS

From a data handling perspective, allocation of VOC and NO_x into chemical classes is similar to the allocation of annual emissions into hourly increments discussed in previous chapters. Basically, as described in Sections 9.3 and 9.4, the VOC (and NO_x) emissions from each point source or area source category (including highway mobile sources) are multiplied by "split factors" to allocate them into classes. A separate file of split factors like the example shown in Table 9-3 for point sources can be created for this purpose; alternatively, the split factors can be stored as part of the emissions data records (molecular weights should be stored similarly).

Note that the file shown in Table 9-3 gives split factors by source category (i.e., at the SCC level) instead of for individual point sources. This file is very similar in format to the split factor files which might be used for area and highway mobile sources (for these sources, the SCC codes in Table 9-3 could be replaced with area source category codes). Compilation of split factors by source category instead of for individual sources is generally recommended, since (1) specific split factors will not be known for most individual facilities, and (2) considerably less file space will be required. One disadvantage of this approach is the difficulty of representing any available source-specific split factor information for individual operations.

Estimates of VOC (and NO_x) by class can either be (1) computed prior to the generation of the model-compatible inventory and stored in the emissions data records or in a separate file, or (2) computed during the creation of the model-compatible inventory to conserve file space. A disadvantage of the latter approach is that VOC (and NO_x) emissions by class have to be recomputed each time a model-compatible inventory is created.

In projection inventories, new VOC and NO_x split factors can be reflected by changing the split factor files and applying them to the projected VOC and NO_x emission totals.

The method for allocating area and mobile source VOC and NO_x into chemical classes is similar to that used for point sources; as mentioned above, an area source split factors file similar to the file shown in Table 9-3 can be created for this purpose. Alternatively, the split factors can be stored in the area source emissions records if space is available. The split factors are multiplied by the VOC (and NO_x) totals to estimate emissions by class.

For mobile sources, separate split factors should be used for each vehicle category for which an emission total is carried along by the network emission calculation model. Ideally, VMT and emissions will be calculated separately for each major vehicle type (e.g., LDGV, HDGV, etc.), in which case vehicle-type-specific VOC and NO_x split factors can be applied. In some instances, however, the model used to generate mobile source emissions estimates may only supply composite emissions for all vehicles, in which case composite split factors will have to be applied based on the fraction of travel by each vehicle type.

TABLE 9-3. Example "split factor" file (excerpt).

Source Category[a] SCC	Pollutant Code[b]	Class 1[c]		Class 2[c]		Class 3[c]		Class 4[c]	
		SF[d]	MW[e]	SF	MW	SF	MW	SF	MW
30600801[f]	HC	34.5	46	56.9	61	7.9	71	.7	96
30600802	HC	13.8	46	75.0	81	3.9	72	7.3	92
30600803	HC	5.0	52	84.0	87	6.6	72	4.4	96
40300106	HC	13.9	58	73.5	61	11.2	72	1.4	92
40300107	HC	13.9	58	73.5	61	11.2	72	1.4	92
40300152	HC	1.1	38	57.3	68	37.0	31	4.6	101
40300205	HC	1.1	38	57.3	68	37.0	31	4.6	101
30000606	NX	85.0	30	15.0	46				
30000608	NX	85.0	30	15.0	46				

[a] Source category by SCC code (eight digits)
[b] Code: HC = VOC, NX = NO_x
[c] Classes are defined as follows:

for VOC: class 1 - nonreactive
class 2 - paraffins
class 3 - olefins
class 4 - aromatics

for NO_x: class 1 - NO
class 2 - NO_2

[d] Split factor, percent of total, by weight
[e] Average molecular weight
[f] Each line constitutes a record, either for VOC or NO_x, for one source category

Since the VOC compositions of the exhaust and evaporative components of mobile source differ significantly, this distinction (if present in the inventory) should be maintained through the VOC allocation process. As discussed in Chapter 7, the MOBILE 4.0 and 4.1 models calculate separate emission factors for exhaust, evaporative, refueling, and running loss emissions from highway motor vehicles; in the absence of additional data, running loss emissions can be speciated using the evaporative loss split factors.

References for Chapter 9

1. User's Guide for the Urban Airshed Model, Volume I: User's Manual for UAM (CB-IV), EPA-450/4-90-007A, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1990.

2. Air Emissions Species Manual, Volume I: Volatile Organic Compound Species Profiles, EPA-450/2-88-003a, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, April 1988.

3. H. Hogo and M. W. Gery, Guidelines for Using OZIPM-4 with CBM-IV or Optional Mechanisms, Volume 1, EPA Contract No. 68-02-4136, Systems Applications Incorporated, 1986.

4. R. J. Milligan et al., Review of NO_x Emission Factors for Stationary Combustion Sources, EPA-450/4-79-021, U.S. Environmental Protection Agency, September 1979.

5. T. W. Tesche and W. R. Oliver, Technical Basis for Refinement of SAI Airshed Model Inputs for the 26 and 27 June, 1974, Multiple-Day Simulation, Systems Applications Inc., November 1981.

6. C. L. Gray, Jr., Motor Vehicle VOC Speciation for SIP Development, Technical Memorandum to John Calcagni and William Laxton, U.S. EPA Office of Air and Radiation, Ann Arbor, MI, March 23, 1989.

GLOSSARY

Activity level - Any variable parameter associated with the operation of a source of emissions which is proportional to the quantity of pollutant emitted.

Anthropogenic emissions - Emissions from man-made sources; commonly subdivided into area, mobile, and point source emissions.

[illegible] source emissions - Emissions which are assumed to occur over a given area rather than at a specified point; often includes emissions from sources considered too [illegible] to be handled individually in the point source [illegible].

Biogenic emissions - Naturally occurring emissions from vegetation.

Carbon bond mechanism - A chemical kinetics mechanism in which various hydrocarbons are grouped according to bond type (e.g., carbon single bonds, carbon double bonds, carbonyl bonds, etc.). This lumping technique categorizes the reactions of similar chemical bonds, whereas the molecular lumping approach groups the reactions of entire molecules.

Concentration background - The concentration of a pollutant in the ambient air of a region as measured by monitors unaffected by sources within the region (i.e., by "upwind" monitors); also referred to as "ambient background concentration."

Effective stack height - The sum of the actual stack height plus the plume rise. It is defined as the height at which a plume becomes passive and subsequently follows ambient air motion.

Emission factor - A factor usually expressed as mass pollutant/throughput or activity level, used to estimate emissions for a given activity.

Emission inventory - A list of the amount of pollutants from all sources entering the air in a given time period. Often includes associated parameters such as process identification and stack parameters.

Emissions modeler - The person or persons responsible for compilation of an emission inventory suitable for photochemical modeling purposes (i.e., spatially, temporally, and chemically resolved).

Evaporative emissions - Emissions resulting from the volatilization of gasoline and solvents due to rising ambient temperatures or engine heat after motor vehicle shutdown.

Exhaust emissions - Emissions resulting from the combustion processes associated with the operation of motor vehicles.

Grid cell - The three-dimensional box-like cell of a grid system.

Grid layer - The horizontal layer of grid cells. The grid model may consist of a number of grid layers.

Grid model - An air quality simulation model that provides estimates of pollutant concentrations for a gridded network of receptors, using assumptions regarding the exchange of air between hypothetical box-like cells in the atmosphere above an emission grid system. Mathematically, this is known as an "Eulerian" model (cf. "Trajectory model").

Growth surrogate - A quantity for which official growth projections are known and whose growth may be assumed similar to that of activity for some source category for which projections are needed.

Julian date - A method of referencing dates in which days are numbered consecutively from an arbitrarily selected point (normally January 1). The form of the date is YYDDD, where YY is the year and DDD is the day; for example, May 3, 1990 = 90123 in Julian notation.

Land use - A description of the major natural or man-made features contained in an area of land or a description of the way the land is being used. Examples of land use categories include forest, desert, cropland, urban, grassland, or wetland areas.

Line source - An emissions source whose spatial distribution is best characterized by assuming emissions occur along a linear path (rather than over an area or at a specific point). Examples of line sources include on-road motor vehicles, railroad locomotives, and shipping vessels.

Link - A surrogate generated to model allocation of line source emissions (see "Line source"). It takes the form of a line, or a group of lines; spatial allocation is performed on the basis of link length per grid cell.

Lumping - In chemical mechanisms, the stratagem of representing certain compounds by surrogate or hypothetical species in order to reduce the assumed number of elementary reactions to a manageable number.

Mobile source emissions - Commonly used to designate emissions from on-road motor vehicles (as opposed to "other mobile" sources; cf. "Line source"). This general category includes emissions from different operational modes (e.g., cold start, hot stabilized, hot start, hot soak, running losses, and diurnal evaporative emissions).

Nitrogen oxides - With respect to air pollutants, nitric oxide (NO) and nitrogen dioxide (NO_2) together comprise nitrogen oxides (NO_x).

Point source emissions - Emissions which are inventoried as occurring at a specified location from a specific process.

Plume rise - The height above a stack at which exit gases rise as a result of the buoyancy effects of the emissions (due either to a temperature higher than the ambient air or the momentum of the emissions as they leave the stack).

Reactivity - Measure of the tendency of a chemical species to react with other species.

Receptor - A hypothetical sensor or monitoring instrument, usually a unit of a hypothetical network overlaid on a map of the area being modeled. Eulerian grid models usually assume one receptor at the center of each grid cell.

Seasonal adjustment - Adjustment of emissions from an annual to a seasonal level, generally based on seasonal variations in activity levels or temperature.

Source - A process or activity resulting in the release of pollutants to the atmosphere.

Source/receptor relationship - A model that predicts ambient pollutant concentrations based on precursor emission levels. Photochemical models are one type of source/receptor relationship.

Spatial allocation surrogate - A quantity whose areal distribution is known or has been estimated and may be assumed similar to that of the emissions from some source category whose areal distribution is unknown.

Spatial resolution - Allocation of emissions to grid cells based on facility location or the distribution of some surrogate indicator. (1) The process of determining or estimating what emissions may be associated with individual grid cells or other subcounty areas, given totals for a larger area such as a county. (2) The degree to which a source can be pinpointed geographically in an emission inventory.

Speciation - Disaggregation of total VOC and NO_x emissions into the chemical species or classes specific to a chemical mechanism, such as the Carbon-Bond Mechanism, employed in a photochemical simulation model.

Speciation profile - Characteristic mix of chemical species in the emissions from a particular activity or group of activities, such as natural gas combustion in an external combustion boiler.

Split factor - The factor by which total VOC or NO_x emissions must be multiplied to give emissions by chemical species or class (e.g., Carbon-Bond species) as required for use in a photochemical simulation model.

Stack parameters - Characteristic parameters of a stack and its associated plume, as required for input to some photochemical simulation models. Typical stack parameters include stack height, inner diameter, volumetric flow rate, and gas exit velocity; stack parameters are required to calculate plume rise.

Temporal resolution - Disaggregation of annual or daily emissions into hourly emissions. (1) The process of determining or estimating what emissions may be associated with various seasons of the year, days of the week, or hours of the day, given annual totals or averages. (2) A measure of the smallest time interval with which emissions can be associated in an inventory.

Throughput - A measure of activity, indicating how much of a substance is handled, produced, or consumed over a given time period.

Trajectory - The path described by a hypothetical parcel of air moved by winds. The air parcel is identified as being at a given location at a given time; the trajectory connects this hypothetical position at any given time with both earlier and later hypothetical positions.

Trajectory model - An air quality simulation model that provides estimates of pollutant concentrations at selected points and times on the trajectories of hypothetical air parcels that move over an emission grid system. Mathematically, this is known as a "Lagrangian" model (cf. "Grid model").

Vertical resolution - Allocation of emissions to vertical layers based on plume calculations. In regard to meteorological parameters and concentrations of pollutants in ambient air, the provision (in a model) of a means for taking into account various values at different heights above ground.

Volatile organic compounds - Any hydrocarbon or other carbon compound present in the gaseous phase in the atmosphere, with the exception of carbon monoxide (CO), carbon dioxide (CO_2), carbonic acid, carbonates, and metallic carbides.

APPENDIX A

CODES FOR EMISSION CATEGORIES

TABLE A-1. Activity codes.
TABLE A-2. Process codes.
TABLE A-3. Control codes.
TABLE A-4. Source category codes.
TABLE A-5. Hydrocarbon speciation profile codes.

TABLE A-1. Activity codes used in the emissions preprocessor system.

Code	Description
100	Resource Development & Agriculture
110	Agricultural Production
111	Agricultural Crops
112	Agricultural Livestock
113	Agricultural Services
120	Forestry
130	Mining
131	Metal Mining
132	Coal Mining
133	Stone & Clay (Mining)
134	Chemicals & Fertilizer Mineral
140	Oil & Gas Extraction
141	Liquid Gas Production
200	Manufacturing & Industrial
210	Food & Kindred Products
211	Fruit/Vegetable Preservation
212	Grain Mill Products
213	Bakery Products
214	Vegetable Oil
215	Sugar Mfg./Refining
216	Malt Beverages
217	Wines & Brandy
220	Lumber & Wood Products
230	Paper & Allied
231	Pulp & Paper Mills
240	Chemical & Allied
241	Rubber & Plastics Manufacturing
242	Drugs
243	Cleaning/Toilet Preparations
244	Paint Manufacturing
245	Agricultural Chemicals
260	Petroleum Refining/Related
261	Petroleum Refining
262	Paving & Roofing Materials
263	Petroleum Coke/Briquette
270	Mineral Products
271	Glass/Glass Products
280	Metallurgical

continued

TABLE A-1. Continued.

Code	Description
281	Iron/Steel Production
282	Iron/Steel Foundry
283	Nonferrous Metals
290	Misc. Manufacturing
291	Textiles & Apparel
292	Furniture & Fixtures
293	Fabricated Metal
294	Machinery
295	Transportation Equipment
296	Rubber & Plastics Fabrication
297	Tobacco Manufacturing
298	Instruments
300	[illegible] & Commerce
310	[illegible] Utilities
320	Petroleum & Gas Marketing
321	[illegible]
322	Service Stations
323	[illegible] Lines
330	Misc. Services
331	Steam Supply
332	Printing & Publishing
333	Laundry & Drycleaners
334	Sanitary & Water
335	Health Services
336	Educational Services
400	Transportation
410	On-road Travel
420	Rail Transport
430	Water Borne
440	Air Transportation
500	Domestic
510	Residential
520	Recreational
600	Misc. Activities
610	Construction
611	Building Construction
612	Road Construction
620	Natural Sources
630	Government

continued

TABLE A-1. Concluded.

Code	Description
631	National Security
801	Seeps/Biogenic
802	Channel Shipping
803	OCS And Related Sources
804	Tideland Platforms
900	Unspecified Activities

TABLE A-2. Process codes used in the emissions preprocessor system.

Code	Description
100	Fuel Combustion
110	Boilers & Heaters
111	Boilers
112	Space Heaters
113	Orchard Heaters
114	Process Heaters
120	In-process Fuel
130	Stationary I.C. Engines
131	Turbine - Combustion Gases
140	Equipment
141	Utility Equipment
142	Mobile Equipment
200	Waste Burning
210	Incineration
211	Conical Burner
220	Open Burning
221	Agricultural Debris
222	Range Improvement
223	Forest Management
300	Solvent Use
310	Dry Cleaning
320	Degreasing
330	Surface Coating
340	Asphalt Paving
350	Printing
400	Liquid Storage & Transfer
410	Tanks
420	Tank Cars & Trucks
430	Marine Vessels
440	Vehicle Refueling
500	Industrial Processes
510	Chemical Processes
520	Food & Agricultural
530	Petroleum & Related
540	Mineral Processes
550	Metal Processes
551	Primary Metal
552	Secondary Metal
553	Metal Fabrication

continued

TABLE A-2. Concluded.

Code	Description
560	Wood & Paper Processes
570	Rubber & Plastics
600	Misc. Processes
610	Pesticide Application
620	Solid Waste Land Fill
621	Waste Disposal
630	Farming Operations
640	Construction & Demolition
650	Road Travel
651	Unpaved Road
652	Paved Road
660	Unplanned Fires
661	Wild Fires
662	Structural Fires
700	Vehicular Sources
710	On-road Motor Vehicles
720	Off-road Motor Vehicles
540	Mineral Processes
550	Metal Processes
551	Primary Metal
552	Secondary Metal
553	Metal Fabrication
560	Wood & Paper Processes
570	Rubber & Plastics
600	Misc. Processes
730	Trains
740	Ships
750	Aircraft
801	Seeps/Biogenic
802	Channel Shipping
803	OCS And Related Sources
804	Tideland Platforms
900	Unspecified Processes

TABLE A-3. Control codes used in the emissions preprocessor system. Abbreviations are defined at the end of the table.

Code	Description
99	Unspecified
101	Utility Boilers - Liquid Fuels
102	Utility Boilers - Gaseous Fuels
103	Refinery Boilers & Heaters - Liquid Fuel
104	Residential Space Heaters - Natural Gas
105	Residential Water Heaters - Natural Gas
107	Non-utility I.C. Engines - Gaseous
108	Utility Reciprocal - Liquids
109	Industrial Boilers
110	Cement Kilns
111	Glass Melting Furnace
112	Marine Diesel Engines
113	Non-farm Equipment (Diesel)
114	Sulfur in Fuel
116	Utility Turbines - Liquids
117	Refinery Boilers & Heaters - Gas. Fuel
118	Steam Generators - Liquids
121	Pipeline Heaters
122	Marine Vessels - Combustion
124	Utility Turbines - Gaseous
125	Cogeneration
126	TEOR Steam Generators - Gaseous
127	Non-utility I.C. Engines - Liquid
128	Resource Recovery
129	Boilers-Space Heaters - Liquid Fuel
130	Boilers-Space Heaters - Gas Fuel
131	Utility Reciprocal - Gaseous
201	Flares
301	Architectural Coatings - Oil Based
302	Architectural Coatings - Water Based
303	Architectural Coatings - Solvents
304	Auto Assembly Line - Surface Coating
305	Auto Assembly Line - Solvent Use
306	Can & Coil - Surface Coating
307	Can & Coil - Solvent Use
308	Metal Parts & Products - Surface Coating
309	Metal Parts & Products - Solvent Use
310	Paper - Surface Coating
311	Paper - Solvent Use

continued

TABLE A-3. Continued.

Code	Description
312	Fabric - Surface Coating
313	Fabric - Solvent Use
314	Degreasing - nonsynthetic & misc. (Industrial)
315	Degreasing - nonsynthetic & misc. (Commercial)
316	Cutback Asphalt Paving Materials
317	Dry Cleaning - nonsynthetic
318	Dry Cleaning - synthetic & misc.
319	Graphic Arts - Except Litho/Letterpress
320	Wood Furniture - Surface Coatings
321	Wood Furniture - Solvent Use
323	Auto Refinishing - Surface Coatings
325	Ships - Surface Coating
326	Ships - Solvent Use
327	Aerospace - Surface Coating
328	Aerospace - Solvent Use
331	Degreasing - Synthetic (Industrial)
332	Degreasing - Synthetic (Commercial)
333	Flatwood Products
334	Graphic Arts - Litho/Letterpress
398	Other Industrial Surface Coating
399	Unspecified Industrial Solvent Use
401	Gasoline Working Loss - Bulk Storage
402	Gasoline Working Loss - Tank Trucks
403	Gasoline Working Losses - Underground Tank
404	Gasoline Working Losses - Vehicle Tank
405	Fixed Roof Tanks at Refineries
406	Floating Roof Tanks at Refineries
407	Marine Vessel Operation - Evaporative
410	Oil Production Fields Storage Tanks
411	Marine Lightering
412	Gasoline Breathing Loss - Underground
413	Gasoline Breathing Loss - Aboveground
501	Refinery Valves, Flanges, & Seals
502	Petroleum Coke Calcining
503	Sulfur Recovery Units
504	Sulfuric Acid Plants
505	Fluid Catalytic Cracking Units
506	Gas-Oil Production - Valves, Flanges, Connectors
507	Small Relief Valves

continued

TABLE A-3. Continued.

Code	Description
508	Non-refinery Valves
510	Vegetable Oil Processing
511	Paint Manufacturing
512	Rubber Products Fabrication
513	Chemical Manufacturing
514	Pharmaceutical Manufacturing
515	Rubber Products Manufacturing
518	Oil Production Steam Drive Well
519	Wineries
520	Carbon Black Manufacturing
522	Pumps & Compressors
523	Refinery Sewers & Drains
524	Refinery Pumps & Compressors
526	Refinery Vacuum System
530	Oil Production - Pump and Compressors
531	Oil Production - Heavy Oil Test Station
532	Oil Production - Cyclic Well Vents
533	Oil Production - Pseudo-cyclic Well
534	Oil Production - Sumps and Pits
535	Natural Gas Plant Fugitives
601	Construction & Demolition
602	Waste Solvent Disposal
603	Pesticides - Synthetic
604	Roofing Tar Pots
605	Pesticides - Nonsynthetic
606	Aerosol Propellant - Synthetic
607	Aerosol Propellant - Nonsynthetic
608	Waste Disposal Landfill
609	Domestic Solvent Use
610	Aerosol Consum Prod Propellant
611	Aerosol Consum Prod Solvent
612	Non-aerosol Consum Prod Solvent
620	Agricultural Pesticide - Synthetic
621	Agricultural Pesticide - Nonsynthetic
622	Other Pesticide - Synthetic
623	Other Pesticide - Nonsynthetic
651	Unpaved City/County Road Dust
711	LDA - Exhaust
712	LDA - Hot Start

continued

TABLE A-3. Continued.

Code	Description
713	LDA - Hot Stabilized
714	LDA - Evaporative
715	LDA - Running Losses
716	LDA - Crankcase Blowby
717	LDA - Tire Wear
718	LD - Refueling
719	Off-road Gasoline Exhaust
720	Off-road Gasoline Evaporative
721	LDT - Cold Start
722	LDT - Hot Start
723	LDT - Hot Stabilized
724	LDT - Hot Soak Evaporative
725	LDT - Diurnal Evaporative
726	LDT - Crankcase Blowby
727	LDT - Tire Wear
731	MDT - Exhaust
732	MDT - Hot Start
733	MDT - Hot Stabilized
734	MDT - Evaporative
735	MDT - Running Losses
736	MDT - Crankcase Blowby
737	MDT - Tire Wear
738	MDT - Refueling
741	HD - Exhaust
742	HD - Evaporative
743	HDG - Hot Stabilized
744	HDG - Evaporative
745	HDG - Running Losses
746	HDG - Crankcase Blowby
747	HDG - Tire Wear
748	HDG - Refueling
751	DDD - Exhaust
753	HDD - Hot Stabilized
757	HDD - Tire Wear
759	Off-road Diesel
761	MCY - Cold Start
762	MCY - Hot Start
763	MCY - Hot Stabilized
764	MCY - Hot Soak Evaporative
765	MCY - Diurnal Evaporative
766	MCY - Crankcase Blowby
767	MCY - Tire Wear

continued

TABLE A-3. Continued.

Code	Description
801	Non-farm Equipment (Gasoline)
802	Farm Equipment (Diesel)
803	Lawn & Garden Equip (Utility)
804	Off-road Motorcycles
805	Pleasure Craft (Boats)
806	Railroad Line Haul Operations
807	Commercial/Civil Piston Aircraft
808	Commercial Jet Aircraft
809	Farm Equipment (gasoline)
811	LDA - Ncat - Cold Start
812	LDA - Ncat - Hot Start
813	LDA - Ncat - Hot Stabilized
814	LDA - Ncat - Hot Soak
815	LDA - Ncat - Diurnal
816	LDA - Ncat - Crankcase
817	LDA - Ncat - Tirewear
821	LDA - Cat - Cold Start
822	LDA - Cat - Hot Start
823	LDA - Cat - Hot Stabilized
824	LDA - Cat - Hot Soak
825	LDA - Cat - Diurnal
827	LDA - Cat - Tirewear
831	LDA - Dsl - Cold Start
832	LDA - Dsl - Hot Start
833	LDA - Dsl - Hot Stabilized
837	LDA - Dsl - Tirewear
841	LMDT - Ncat - Cold Start
842	LMDT - Ncat - Hot Start
843	LMDT - Ncat - Hot Stabilized
844	LMDT - Ncat - Hot Soak
845	LMDT - Ncat - Diurnal
846	LMDT - Ncat - Crankcase
847	LMDT - Ncat - Tirewear
851	LMDT - Cat - Cold Start
852	LMDT - Cat - Hot Start
853	LMDT - Cat - Hot Stabilized
854	LMDT - Cat - Hot Soak
855	LMDT - Cat - Diurnal
857	LMDT - Cat - Tirewear
861	LMDT - Dsl - Cold Start
862	LMDT - Dsl - Hot Start
863	LMDT - Dsl - Hot Stabilized

continued

TABLE A-3. Concluded.

Code	Description
867	LMDT - Dsl - Tirewear
873	HDT - Ncat - Hot Stabilized
874	HDT - Ncat - Hot Soak
875	HDT - Ncat - Diurnal
876	HDT - Ncat - Crankcase
877	HDT - Ncat - Tirewear
883	HDT - Cat - Hot Stabilized
884	HDT - Cat - Hot Soak
885	HDT - Cat - Diurnal
887	HDT - Cat - Tirewear
891	Seeps/Biogenic
892	Channel Shipping
893	OCS and Related Sources
894	Tideland Platforms
901	Forest Management Control Burning
902	Wild Fires Control Burning
903	Livestock Waste
999	Misc. Control Tactics

Cat = catalytic
Ncat = noncatalytic
Dsl - diesel
LDA = light-duty auto
LDT = light-duty truck
LMDT = light-medium-duty truck
MDT = medium-duty truck
HDG = heavy-duty gas
HDD = heavy-duty diesel
MCY = motorcycle

TABLE A-4. Source category codes used in the emissions preprocessor system.

Code	Description
100	Fuel Combustion
110	Agricultural
120	Oil and Gas Production
130	Petroleum Refining
140	Other Manufacturing/Industrial
150	Electric Utilities
160	Other Services and Commerce
170	Residential
199	Other
200	Waste Burning
210	Agricultural Debris
220	Range Management
230	Forest Management
240	Incineration
299	Other
300	Solvent Use
310	Dry Cleaning
320	Degreasing
330	Architectural Coating
340	Other Surface Coating
350	Asphalt Paving
360	Printing
370	Domestic
380	Industrial Solvent Use
399	Other
400	Petroleum Process, Storage & Transfer
410	Oil and Gas Extraction
420	Petroleum Refining
430	Petroleum Marketing
499	Other
500	Industrial Processes
510	Chemical
520	Food and Agricultural
560	Mineral Processes
570	Metal Processes
580	Wood and Paper
599	Other
600	Misc Processes

continued

TABLE A-4. Concluded.

Code	Description
610	Pesticide Application
620	Farming Operations
630	Construction and Demolition
640	Entrained Road Dust - Paved
650	Entrained Road Dust - Unpaved
660	Unplanned Fires
680	Waste Disposal
685	Natural Sources
699	Other
700	On Road Vehicles
710	Light Duty Passenger
720	Light and Medium Duty Trucks
730	Heavy Duty Gas Trucks
740	Heavy Duty Diesel Trucks
750	Motorcycles
799	Other
800	Other Mobile
810	Off Road Vehicles
820	Trains
830	Ships
850	Aircraft - Government
860	Aircraft - Other
870	Mobile Equipment
880	Utility Equipment
891	Seeps/Biogenic
892	Channel Shipping
893	OCS and Related Sources
894	Tideland Platforms
900	Unspecified Sources

TABLE A-5. Hydrocarbon speciation profile codes used in the emissions preprocessor system. (Based on EPA, 1988)

Code	Description
0000	Overall Average
0001	External Combustion Boiler - Residual Oil
0002	External Combustion Boiler - Distillate Oil
0003	External Combustion Boiler - Natural Gas
0004	External Combustion Boiler - Refinery Gas
0005	External Combustion Boiler - Coke Oven Gas
0007	Natural Gas Turbine
0008	Reciprocating Diesel Fuel Engine
0009	Reciprocating Distillate Oil Engine
0011	By-Product Coke Oven Stack Gas
0012	Blast Furnace Ore Charging and Agglomerate
0013	Iron Sintering
0014	Open Hearth Furnace with Oxygen Lance
0016	Basic Oxygen Furnace
0023	Asphalt Roofing - Spraying
0024	Asphalt Roofing - Tar Kettle
0025	Asphaltic Concrete - Natural Gas Rotary Dryer
0026	Asphaltic Concrete - In Place Road Asphalt
0029	Refinery Fluid Catalytic Cracker
0031	Refinery Fugitive Emissions-Covered Drainage/Separation Pits
0035	Refinery Fugitive Emissions - Cooling Towers
0039	Refinery Fugitive Emissions - Compressor Seals Refinery Gas
0047	Refinery Fugitive Emissions - Relief Valves, Liquified Petroleum Gas
0051	Natural Gas
0066	Varnish Manufacturing - Bodying Oil
0068	Manufacturing - Plastics - Polypropylene
0072	Printing Ink Cooking
0076	General Pesticides
0078	Ethylene Dichloride - Direct Chlorination
0079	Chemical Manufacturing - Flares
0085	Perchloroethylene - Drycleaning
0087	Degreasing - 1,1,1-Trichloroethane
0088	Degreasing - Trichlorofluoromethane (Freon 11)
0089	Degreasing - 1,1,2-Trichloroethane
0090	Degreasing - Toluene
0100	Fixed Roof Tank - Commercial Jet Fuel (Jet-A)
0121	Open Burning Dump - Landscape/Pruning
0122	Bar Screen Waste Incinerator
0127	Surface Coating - Varnish/Shellac

continued

TABLE A-5. Continued.

Code	Description
0166	Printing Press - Letterpress Inking Process
0182	Printing Press - Gravure General Solvent
0183	Printing Press - Gravure Printing Solvent
0195	Residential Fuel - Natural Gas
0197	Solvent Use - Domestic Solvents
0202	Solid Waste Landfill Site - Class II
0203	Solid Waste - Animal Waste Decomposition
0217	Coke Oven Blast Furnace Gas
0219	Surface Coating Paint Solvent - Acetone
0220	Paint Solvent - Ethyl Acetate
0221	Paint Solvent - Methyl Ethyl Ketone
0222	Surface Coating - Enamel - Cellosolve Acetate
0223	Surface Coating - Varnish/Shellac Solvent - Xylene
0225	Surface Coating - Primer- Mineral Spirits
0226	Surface Coating Solvent - Ethyl Alcohol
0227	Surface Coating Solvent - Isopropyl Alcohol
0228	Surface Coating Solvent - Isopropyl Acetate
0229	Surface Coating Solvent - Lactol Spirits
0230	Fixed Roof Tank - Hexane
0271	Degreasing - Trichloroethylene
0272	Automotive Tires - Tuber Adhesive
0273	Automotive Tires - Tuber Adhesive White Sidewall
0274	Automotive Tire Production
0275	Degreasing - Dichloromethane
0277	Degreasing - Trichlorotrifluoroethane (Freon 113)
0282	Surface Coating Primer - Naphtha
0288	Surface Coating Solvent - Butyl Acetate
0289	Surface Coating Solvent - Butyl Alcohol
0290	Surface Coating Solvent - Cellosolve
0291	Surface Coating Solvent - Methyl Alcohol
0292	Surface Coating Solvent - Dimethylformamide
0296	Fixed Roof Tank - Crude Oil Production
0297	Fixed Roof Tank - Crude Oil Refinery
0299	Fixed Roof Tank - Cyclohexane
0301	Fixed Roof Tank - Heptane
0304	Printing Press - Flexographic, n-Propyl Alcohol
0305	Fixed Roof Tank - Crude Oil Marine Terminal
0307	Miscellaneous Burning - Forest Fires
0316	Pipe/Valve Flanges

continued

TABLE A-5. Continued.

Code	Description
0321	Pump Seals - Composite
0332	Printing Press - Lithography Inking and Drying
0333	Lithography - Inking and Drying-Direct Fired Dryer
1001	Internal Combustion Engine - Natural Gas
1002	Chemical Menufacturing - Carbon Black Production
1003	Surface Coating Operations - Coating Application - Solvent-base Paint
1004	Plastics Production - Polystyrene
1005	Plastics Production - Polyester Resins
1006	Phthalic Anhydride - o-Xylene Oxidation - Main Process Stream
1007	Mineral Products - Asphaltic Concrete
1008	Rubber and Misc. Plastics Products - Styrene/Butadiene
1009	Plastics Production - Acrylonitrile - Butadiene - Styrene Resin
1010	Oil and Gas Production - Fugitives - Unclassified
1011	Oil and Gas Production - Fugitives - Valves and Fittings - Liquid Service
1012	Oil and Gas Production - Fugitives - Valves and Fittings - Gas service
1013	Surface Coating Operations - Coating Application - Water-base Paint
1014	Gasoline - Summer Blend
1015	Gasoline - Winter Blend
1016	Surface Coating Operations - Thinning Solvents - Composite
1017	Surface Coating Operations - Coating Application - Lacquer
1018	Surface Coating Operations - Coating Application - Enamel
1019	Surface Coating Operations - Coating Application - Primer
1020	Surface Coating Operations - Coating Application - Adhesives
1021	Degreasing - Open Top - Chlorosolve
1022	Printing/Publishing - Ink Thinning Solvents - Methyl Isobutyl Ketone
1023	Terephthalic Acid/Dimethyl Terephthalate - Crystal-, Separat-, Drying Vat
1024	Terephthalic Acid/Dimethyl Terephthalate - Distillation and Recovery Vent
1025	Terephthalic Acid/Dimethyl Terephthalate - Product Transfer Vent
1026	Surface Coating Operations - Thinning Solvent - Hexylene Glycol
1027	Ketone Production - Methyl Ethyl Ketone (MEK)
1028	Acetone - Light Ends Distillation Vent
1029	Acetone - Acetone Finishing Column
1030	Aldehydes Production - Formaldehyde - Absorber Vent
1031	Surface Coating Operations - Thinning Solvent - Ethylene Oxide
1032	Aldehydes Production - Acrolein - Distillation System
1033	Aldehydes Production - Acrolein - Reactor Blowoff Gas
1034	Chloroprene - Butadiene Dryer

continued

TABLE A-5. Continued.

Code	Description
1035	Chloroprene - Chloroprene Stripper and Brine Stripper
1036	Secondary Aluminum - Pouring and Casting
1037	Organohalogens - Ethylene Dichloride - Direct Chlorination - Distillation Ven
1038	Organohalogens Production - Ethylene Dichloride - Via Oxychlorination
1039	Organohalogens Production - Ethylene Dichloride - Caustic Scrubber
1040	Fluorocarbons/Chlorofluorocarbons - General
1041	Fluorocarbons/Chlorofluorocarbons - Distillation Column
1042	Fluorocarbons/Chlorofluorocarbons - Fugitive Emissions - General
1043	Acrylic Acid - Quench Absorber
1044	Organic Acids Production - Formic Acid
1045	Organic Acids Production - Acetic Anhydride - Distillation Column Vent
1046	Esters Production - Acrylates - Ethyl Acrylate
1047	Esters Production - Butyl Acrylate
1048	Cumene Production - Cumene Distillation System Vent
1049	Cyclohexane - General
1050	Cyclohexanone/Cyclohexanol - Phenol Hydrogenation Process - Distillation Vent
1051	Vinyl Acetate - Inert Gas Purge Vent
1052	Vinyl Acetate - CO2 Purge Vent
1053	Vinyl Acetate - Inhibitor Mix Tank Discharge
1054	Vinyl Acetate - Refining Column Vent
1055	Organic Chemical Storage - Methylamyl Ketone
1056	Ethylene Oxide - Oxygen Oxidation Process Reactor - CO2 Purge Vent
1057	Ethylene Oxide - Oxygen Oxidation Process Reactor - Argon Purge Vent
1058	Ethylene Oxide - Stripper Purge Vent
1059	Methyl Methacrylate (MMA) - Hydrolysis Reactor, Light Ends. Distillation Unit
1060	Methyl Methacrylate (MMA) - Acid Distillation and MMA Purification
1061	Nitrobenzene - Reactor and Separator Vent - Washer and Neutralizer Vent
1062	Benzene
1064	Olefins Production - Ethylene - Compressor Lube Oil Vent
1065	Propylene Oxide - Chlorohydronation Process - General
1066	Styrene - General
1067	Styrene - Benzene Recycle
1068	Styrene - Styrene Purification
1069	Organic Chemical Storage - N-Propyl Acetate
1070	Alcohols Production - Methanol - Purge Gas Vent
1071	Alcohols Production - Methanol - Distillation Vent

continued

TABLE A-5. Continued.

Code	Description
1072	Chlorobenzene - Tail Gas Scrubber
1073	Chlorobenzene - Benzene Drying Distillation
1074	Monochlorobenzene
1075	Chlorobenzene - Vacuum System Vent
1076	Chlorobenzene - Dichlorobenzene Crystallization
1077	Chlorobenzene - Dichlorobenzene Crystal Handling/Loading
1078	Railcar Cleaning - Low Vapor Press., High Viscosity Cargo (Ethylene Glycol)
1079	Railcar Cleaning - Low Vapor Press., Medium Viscosity Cargo (o-Dichlorobenzene)
1080	Railcar Cleaning - Low Vapor Pressure, High Viscosity Cargo (Creosote)
1081	Tank Truck Cleaning - Med. Vapor Press., Med Visc. Cargo (Methyl Methacrylate)
1082	Tank Truck Cleaning - Low Vapor Pressure, Low Viscosity Cargo (Phenol,
1083	Tank Truck Cleaning - Low Vapor Press., High Visc.Cargo (Propylene Glycol)
1084	Residential Wood Combustion (C1-C6)
1085	External Combustion Boiler - Coal-Slurry Fired
1086	Printing/Flexographic
1087	Organic Chemical Storage/i-Butyl i-Butyrate
1088	Surface Coating Operations - Adhesive Application
1089	Secondary Metal Production - Gray Iron Foundries - Pouring/Casting
1090	Fluorocarbon Manufacturing - CF 12/11
1091	Plastics Production - Polyvinyl Chlorides and Copolymers
1092	Synthetic Organic Fiber Production - Nylon Batch Production Process
1093	Fluorocarbon Manufacturing - CF 23/22
1094	Paint Manufacture - Blending Kettle
1095	Textile Products - General Fabric Operations - Dyeing and Curing
1096	Textile Products - General Fabric Operations - Tenter Frame
1097	Aircraft Landing/Takeoff (LTO) - Military
1098	Aircraft Landing/Takeoff (LTO) - Commercial
1099	Aircraft Landing/Takeoff (LTO) - General Aviation
1100	Gasoline Refueling
1101	Light Duty Gasoline Vehicles
1103	1-Pentene
1104	Acetaldehyde
1105	Acetic Acid
1106	Acetic Anhydride
1107	Acrolein

continued

TABLE A-5. Continued.

Code	Description
1108	Acrylic Acid
1109	Acrylonitrile
1110	Adipic Acid
1111	Aniline
1112	Benzyl Chloride
1114	Butyl Acrylate
1115	Butyl Carbitol
1116	Butyl Cellosolve
1118	Carbitol
1119	Carbon Tetrachloride
1120	Acetylene
1121	Chloroform
1122	Cresol
1123	Cumene
1124	Cyclohexanol
1125	Cyclohexanone
1126	Cyclopentene
1127	Diethylene Glycol
1128	Diisopropyl Benzene
1129	Dipropylene Glycol
1130	Dodecene
1131	Epichlorohydrin
1132	Ethanolamines
1134	Ethyl Acrylate
1135	Ethyl Benzene
1136	Ethyl Ether
1137	Ethyl Mercaptan
1138	Ethyl Dibromide
1139	Ethyleneamines
1140	Formaldehyde
1141	Formic Acid
1142	Furfural
1144	Heptenes
1145	Isobutyraldehyde
1146	Isobutyl Acrylate
1147	Isobutyl Alcohol
1148	Isoprene
1149	Methanol
1150	Methyl Acetate

continued

TABLE A-5. Continued.

Code	Description
1151	Methyl Acrylate
1152	Methyl Carbitol
1153	Methyl Cellosolve
1154	Methyl Styrene
1155	Methylallene
1158	Methyl t-Butyl Ether
1159	m-Xylene
1160	Nitrobenzene
1162	N-Butyraldehyde
1163	N-Decane
1164	N-Dodecane
1165	o-Xylene
1166	Pentadecane
1167	Residential Wood Combustion
1168	Piperylene
1171	Propionaldehyde
1172	Propionic Acid
1173	Propylene Oxide
1174	p-Xylene
1175	Tert-Butyl Alcohol
1176	Toluene Diisocyanate
1178	Coal-Fired Boiler - Electric Generation
1185	Coal-Fired Boiler - Industrial
1186	Heavy-Duty Gasoline Trucks
1187	Citrus Coating
1188	Fermentation Processes
1189	Pulp and Paper Industry - Plywood Veneer Dryer
1190	Gasoline Marketed
1191	Graphic Arts - Printing
1192	Degreasing
1193	Drycleaning
1194	Auto Body Repair
1195	Degreasing Composite
1196	Drycleaning Composite
1197	Isooctane
1198	Pentane
1199	Isopentane
1200	Cyclopentane
1201	Light-Duty Diesel Vehicles

continued

TABLE A-5. Continued.

Code	Description
1202	Primary Aluminum Production
1203	Light-Duty Gasoline Vehicles - Exhaust Emissions
1204	Light-Duty Gasoline Vehicles - Evaporative Emissions
9001	External Combustion Boilers - Industrial - Average
9002	Internal Combustion - Average
9003	Industrial Processes - Average
9004	Chemical Manufacturing - Average
9005	Plastics Production - Average
9006	Synthetic Organic Fiber Production - Average
9007	Alcohols Production - Average
9008	Food and Agriculture - Average
9009	Primary Metal Production - Average
9010	Secondary Metal Production - Average
9011	Mineral Products - Average
9012	Petroleum Industry - Average
9013	Pulp and Paper Industry - Average
9014	Rubber and Miscellaneous Plastics Products - Average
9015	Oil and Gas Production - Average
9016	Textile Products - Average
9017	Drycleaning/Degreasing - Average
9021	Surface Coating Operations - Average
9022	Solid Waste Disposal - Average
9023	Thinning Solvents - Average
9024	Petroleum Product Storage - Average
9025	Bulk Terminals - Petroleum Storage Tanks - Average
9026	Printing/Publishing - Average
9027	Transportation and Marketing of Petroleum Products - Average
9028	Organic Chemical Storage - Average
9029	Organic Chemical Storage - Fixed Roof Tanks - Alcohols - Average
9030	Organic Chemical Storage - Fixed Roof Tanks - Alkanes - Average
9031	Organic Chemical Storage - Fixed Roof Tanks - Alkenes - Average
9032	Organic Chemical Storage - Fixed Roof Tanks - Amines - Average
9033	Organic Chemical Storage - Fixed Roof Tanks - Aromatics - Average
9034	Organic Chemical Storage - Fixed Roof Tanks - Carboxylic Acids - Average
9035	Organic Chemical Storage - Fixed Roof Tanks - Esters - Average
9036	Organic Chemical Storage - Fixed Roof Tanks - Glycol Ethers - Average
9037	Organic Chemical Storage - Fixed Roof Tanks - Glycols - Average

continued

TABLE A-5. Concluded.

Code	Description
9038	Organic Chemical Storage - Fixed Roof Tanks - Halogenated Organics - Average
9039	Organic Chemical Storage - Fixed Roof Tanks - Isocyanates - Average
9040	Organic Chemical Storage - Fixed Roof Tanks - Ketones - Average
9041	Organic Chemical Storage - Floating Roof Tanks - Aldehydes - Average
9042	Organic Chemical Storage - Floating Roof Tanks - Alkanes - Average
9043	Organic Chemical Storage - Floating Roof Tanks - Ethers - Average
9044	Organic Chemical Storage - Floating Roof Tanks - Halogenated Organics - Average
9046	Organic Chemica. Storage - Pressure Tanks - Alkenes - Average
9047	Organic Solvent Evaporation - Miscellaneous - Average

APPENDIX B

DEVELOPMENT OF LOCALE-SPECIFIC EMISSION INVENTORIES FOR USE WITH THE URBAN AIRSHED MODEL

Technical Memorandum

DEVELOPMENT OF LOCALE-SPECIFIC EMISSION INVENTORIES FOR USE WITH THE URBAN AIRSHED MODEL

SYSAPP-90/109

29 October 1990

Prepared for

David C. Misenheimer
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina

Prepared by

LuAnn Gardner
Marianne C. Causley
Lyle R. Chinkin

Systems Applications International
101 Lucas Valley Road
San Rafael, California 94903
(415) 507-7100

Abstract

This memorandum discusses methods for incorporation of locale-specific information into a photochemical modeling emission inventory. The emission inventory requirements of the Urban Airshed Model (UAM) and the UAM Emission Preprocessor System (EPS), Version 1.00, developed for EPA by Systems Applications International, are briefly reviewed. Types of locale-specific data incorporation addressed include the following:

- Spatially allocating emissions using distribution surrogates and/or link data;
- Temporally distributing and adjusting emissions;
- Generating or adjusting mobile source inventories using episode-specific parameters;
- Speciating VOC emissions;
- Projecting future year inventories;
- Adding source categories; and
- Incorporating biogenic emissions.

For each of the topics listed above, we provide a detailed discussion of modification of EPS input files to accommodate locale-specific data and supplemental software requirements.

I. INTRODUCTION

This memorandum briefly discusses the emission inventory input requirements of the Urban Airshed Model (UAM) and identifies methods by which locale-specific data can be incorporated into a modeling inventory. The UAM Emission Preprocessor System (EPS), Version 1.00, available from EPA, conveniently packages a series of programs that perform the intensive data manipulations required to develop an emission inventory suitable for UAM modeling with minimal additional resource requirements. To avoid unnecessary duplication of these manipulations by the user, this document addresses the incorporation of locale-specific data from the perspective of modifying EPS and its inputs.

The UAM Emission Preprocessor System (EPS) contains a set of default inputs representative of national average parameters. If these defaults are inappropriate for the region or modeling episode in question, they can be modified or supplementary code to the existing EPS modules can be developed to incorporate locale-specific data into the modeling inventory. Specific topics discussed include spatial allocation, temporal adjustment, mobile source parameters, VOC and NOx speciation into carbon-bond classes, projection of future year inventories, and inclusion of biogenic emissions.

II. BACKGROUND

The UAM (the photochemical model currently recommended by EPA) is a three-dimensional grid model employing carbon-bond chemistry. Concentrations of ozone and ozone precursor emissions by hour and by grid cell are calculated by simulating the various physical and chemical processes which take place in the atmosphere. This spatial and temporal resolution of the concentration field requires that a detailed emission inventory of hourly emissions by grid cell of photochemically reactive species (CO, NOx, and VOC) be used as input to the UAM. VOC emissions must be further disaggregated into individual chemicals, which are then grouped into carbon-bond classes; NOx emissions must be separated into NO and NO2. Additionally, stack parameters (including height, diameter, gas temperature, and exit velocity or flow rate) are required so that point source emissions can be correctly allocated to vertical layers.

Under contract to EPA, Systems Applications International developed the software package known as the UAM Emission Preprocessor System (EPS), Version 1.00, to facilitate development of the detailed photochemical modeling emission inventories required by the UAM. Emissions from a county-level annual inventory such as NAPAP are spatially allocated using a combination of specified location data (for point sources), spatial allocation surrogates such as population and landuse (for area sources), and optional link data (for mobile sources such as motor vehicles, aircraft, railway locomotives, and vessels). Emissions are temporally adjusted from annual totals (tons per year) to episode-specific levels and diurnally distributed using source-specific operating information or typical activity profiles by source category. Finally, emissions are disaggregated into carbon-bond classes using EPA VOC speciation profiles by source classification code. Figure 1 provides an overview of EPS; Table 1 indicates primary functions of each of the EPS modules.

The EPS package includes input files containing default parameters such as temporal distribution and speciation profiles by source type. The user must supply (1) a gridded field of spatial allocation surrogates for the modeling domain, (2) optional link data for spatial allocation of mobile source emissions, (3) factors to adjust on-road motor vehicle emissions from annual-average to episodic levels, and (4) a set of projection factors for development of future year emission inventories.

In addition to the user-specified inputs listed above, other types of locale-specific data can be incorporated into the modeling inventory to make it more representative of the region and episode of interest. This memorandum describes the types of locale-specific information which may be collected for both baseline and future year inventories and discusses how to compile this information into data bases appropriate for interfacing with EPS or otherwise assimilate such data into the photochemical modeling inventory. For detailed descriptions of the data formats required by EPS, see the User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emission Preprocessor System (SAI, 1990).

Table 2 shows the information required by EPS for point and area source annual emission data bases. Since EPS was developed specifically for use with the NAPAP inventory, area source category designations compatible with those used in NAPAP should be maintained. Otherwise, additional modification to EPS may be required, including changes in program code as well as input files (these modifications are discussed further below). A list of the area source categories currently supported by EPS is provided in Table 3.

III. SPATIAL ALLOCATION OF EMISSIONS

The annual point source inventory generally includes location information for each point source (reported as either latitude and longitude or UTM coordinates), allowing direct assignment of emissions to grid cells. If locations are available in UTM coordinates, minor code modifications to the EPS module PREPNT will be necessary (EPS was designed specifically for use with the NAPAP emissions data base, in which point source locations are designated by latitude and longitude).

Unlike point source emissions, area and mobile source emissions are often reported as county-level totals in an annual inventory; emissions from these sources must consequently be disaggregated to grid cells. Generally, spatial allocation surrogates are

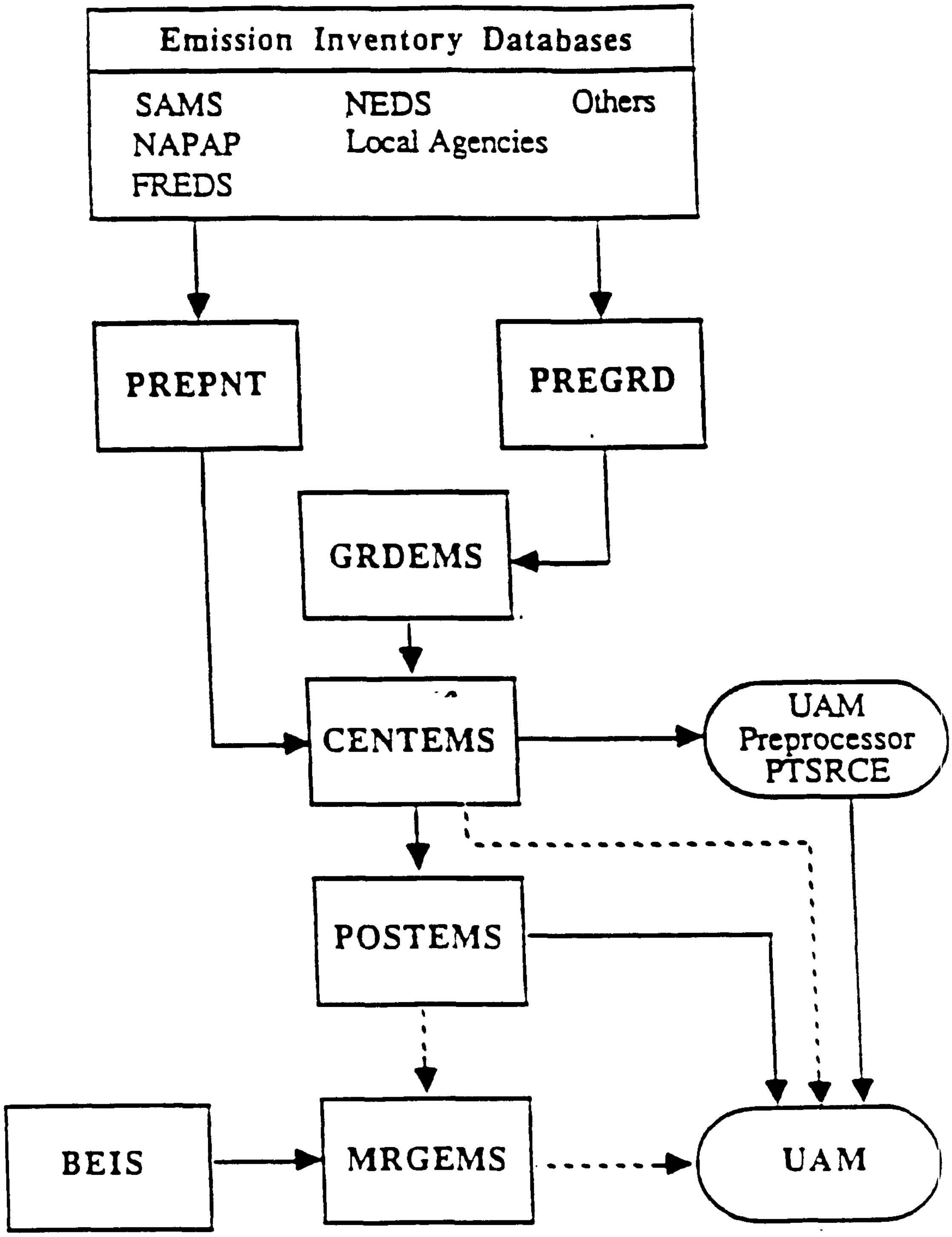


FIGURE 1. Overview of EPS program modules.

TABLE 1. Primary functions of EPS modules.

Module	Functions
PREPNT	• spatially allocate point source emissions • assign temporal distribution codes based on operating information • identify stacks to be treated as elevated sources based on calculated plume rise
PREGRD	• separate area and on-road motor vehicle emissions into different files • disaggregate mobile emissions into exhaust, evaporative, running losses, and refueling losses by vehicle type • adjust mobile emissions for episodic conditions (temperature, RVP, fleet turnover effects, etc.)
GRDEMS	• spatially allocate area and mobile source emissions using spatial surrogates and link data • assign temporal distribution codes by source category
CENTEMS	• adjust annual-average daily emissions by month of year and day of week to episodic levels • allocate emissions by hour • remove non-reactive fraction from total hydrocarbon emissions • assign emissions to carbon bond classes • create emissions input file for the UAM elevated point source preprocessor program, PTSRCE • create a UAM-ready low-level emissions file
POSTEMS	• merge up to six low-level anthropogenic UAM emissions files into one file • create a summary report describing the merged inventory
MRGEMS	• merge two low-level UAM emissions files into one file (generally used to merge anthropogenic and biogenic files)

TABLE 2. Information required by EPS for each record of the annual average inventory.

Point source inventory	
	• state and county identification codes
	• facility and point identification codes
	• process identification codes (SIC, SCC)
	• location
	• stack parameters (exhaust gas flow rate, stack height and diameter, temperature)
	• operating schedule (seasonal throughputs and weeks per year, days per week, and hours per day in operation
	• annual average emissions
	• range of points sharing a common stack (optional)
Area and mobile source inventory	
	• state and county identification codes
	• source category code
	• annual average emissions by county

TABLE 3. NAPAP area source category codes.

NAPAP Area Source Category	
1	Residential Fuel - Anthracite Coal
2	Residential Fuel - Bituminous Coal
3	Residential Fuel - Distillate Oil
4	Residential Fuel - Residual Oil
5	Residential Fuel - Natural Gas
6	Residential Fuel - Wood
7	Commercial/Institutional Fuel - Anthracite Coal
8	Commercial/Institutional Fuel - Bituminous Coal
9	Commercial/Institutional Fuel - Distillate Oil
10	Commercial/Institutional Fuel - Residual Oil
11	Commercial/Institutional Fuel - Natural Gas
12	Commercial/Institutional Fuel - Wood
13	Industrial Fuel - Anthracite Coal
14	Industrial Fuel - Bituminous Coal
15	Industrial Fuel - Coke
16	Industrial Fuel - Distillate Oil
17	Industrial Fuel - Residual Oil
18	Industrial Fuel - Natural Gas
19	Industrial Fuel - Wood
20	Industrial Fuel - Process Gas
21	On-Site Incineration - Residential
22	On-Site Incineration - Industrial
23	On-Site Incineration - Commercial/Institutional
24	Open Burning - Residential
25	Open Burning - Industrial
26	Open Burning - Commercial/Institutional
27	Light Duty Gasoline Vehicles - Limited Access Roads
28	Light Duty Gasoline Vehicles - Rural Roads
29	Light Duty Gasoline Vehicles - Suburban Roads
30	Light Duty Gasoline Vehicles - Urban Roads
31	Medium Duty Gasoline Vehicles - Limited Access Roads
32	Medium Duty Gasoline Vehicles - Rural Roads
33	Medium Duty Gasoline Vehicles - Suburban Roads
34	Medium Duty Gasoline Vehicles - Urban Roads
35	Heavy Duty Gasoline Vehicles - Limited Access Roads
36	Heavy Duty Gasoline Vehicles - Rural Roads
37	Heavy Duty Gasoline Vehicles - Suburban Roads
38	Heavy Duty Gasoline Vehicles - Urban Roads
39	Off Highway Gasoline Vehicles
40	Heavy Duty Diesel Vehicles - Limited Access Roads
41	Heavy Duty Diesel Vehicles - Rural Roads

TABLE 3. Continued.

NAPAP Area Source Category
42 Heavy Duty Diesel Vehicles - Suburban Roads
43 Heavy Duty Diesel Vehicles - Urban Roads
44 Off Highway Diesel Vehicles
45 Railroad Locomotives
46 Aircraft LTOs - Military
47 Aircraft LTOs - Civil
48 Aircraft LTOs - Commercial
49 Vessels - Coal
50 Vessels - Diesel Oil
51 Vessels - Residual Oil
52 Vessels - Gasoline
53 (NOT USED)
54 Gasoline Marketed
55 Unpaved Road Travel
56 Unpaved Airstrip LTOs
57 (NOT USED)
58 (NOT USED)
59 (NOT USED)
60 Forest Wild Fires
61 Managed Burning - Prescribed
62 Agricultural Field Burning
63 Frost Control - Orchard Heaters
64 Structural Fires
65 (NOT USED)
66 Ammonia Emissions - Light Duty Gasoline Vehicles
67 Ammonia Emissions - Heavy Duty Gasoline Vehicles
68 Ammonia Emissions - Heavy Duty Diesel Vehicles
69 Livestock Waste Management - Turkeys
70 Livestock Waste Management - Sheep
71 Livestock Waste Management - Beef Cattle
72 Livestock Waste Management - Dairy Cattle
73 Livestock Waste Management - Swine
74 Livestock Waste Management - Broilers
75 Livestock Waste Management - Other Chickens
76 Anhydrous Ammonia Fertilizer Application
77 Beef Cattle Feed Lots
78 Degreasing
79 Dry Cleaning
80 Graphic Arts/Printing
81 Rubber and Plastics manufacture
82 Architectural Coatings

TABLE 3. Continued.

NAPAP Area Source Category	
83	Auto Body Repair
84	Motor Vehicle Manufacture
85	Paper Coating
86	Fabricated Metals
87	Machinery Manufacture
88	Furniture Manufacture
89	Flatwood Products
90	Other Transportation Equipment Manufacture
91	Electrical Equipment Manufacture
92	Shipbuilding and Repairing
93	Miscellaneous Industrial Manufacture
94	(NOT USED)
95	Miscellaneous Solvent Use
96	Minor Point Sources - Coal Boilers
97	Minor Point Sources - Oil Boilers
98	Minor Point Sources - Natural Gas Boilers
99	Minor Point Sources - Other
100	Publicly Owned Treatment Works (POTWs)
101	Cutback Asphalt Paving Operation
102	Fugitives from Synthetic Organic Chemical Manufacture
103	Bulk Terminals and Bulk Plants
104	Fugitives from Petroleum Refinery Operations
105	Process Emissions from Bakeries
106	Process Emissions from Pharmaceutical Manufacture
107	Process Emissions from Synthetic Fibers Manufacture
108	Crude Oil and Natural Gas Production Fields
109	Hazardous Waste Treatment, Storage and Disposal Facilities (TSDFs)

[illegible]-expanded NAPAP source category codes for motor vehicle emissions:

Exhaust Emissions:

27	LDGV - Limited Access Roads
28	LDGV - Rural Roads
29	LDGV - Suburban Roads
30	LDGV - Urban Roads
31	MDGV - Limited Access Roads
32	MDGV - Rural Roads
33	MDGV - Suburban Roads
34	MDGV - Urban Roads
35	HDGV - Limited Access Roads

TABLE 3. Continued.

Exhaust Emissions (cont.):

36	HDGV - Rural Roads	
37	HDGV - Suburban Roads	
38	HDGV - Urban Roads	
39	Off Highway Gasoline Vehicles	
40	HDDV - Limited Access Roads	
41	HDDV - Rural Roads	
42	HDDV - Suburban Roads	
43	HDDV - Urban Roads	
44	Off Highway Diesel Vehicles	

Evaporative Emissions:

227	LDGV - Limited Access Roads	(SAI NSC)
228	LDGV - Rural Roads	(SAI NSC)
229	LDGV - Suburban Roads	(SAI NSC)
230	LDGV - Urban Roads	(SAI NSC)
231	MDGV - Limited Access Roads	(SAI NSC)
232	MDGV - Rural Roads	(SAI NSC)
233	MDGV - Suburban Roads	(SAI NSC)
234	MDGV - Urban Roads	(SAI NSC)
235	HDGV - Limited Access Roads	(SAI NSC)
236	HDGV - Rural Roads	(SAI NSC)
237	HDGV - Suburban Roads	(SAI NSC)
238	HDGV - Urban Roads	(SAI NSC)
239	Off Highway Gasoline Vehicles	(SAI NSC)
240	HDDV - Limited Access Roads	(SAI NSC)
241	HDDV - Rural Roads	(SAI NSC)
242	HDDV - Suburban Roads	(SAI NSC)
243	HDDV - Urban Roads	(SAI NSC)
244	Off Highway Diesel Vehicles	(SAI NSC)

Refueling Loss Emissions:

327	LDGV - Limited Access Roads	(SAI NSC)
328	LDGV - Rural Roads	(SAI NSC)
329	LDGV - Suburban Roads	(SAI NSC)
330	LDGV - Urban Roads	(SAI NSC)
331	MDGV - Limited Access Roads	(SAI NSC)
332	MDGV - Rural Roads	(SAI NSC)
333	MDGV - Suburban Roads	(SAI NSC)
334	MDGV - Urban Roads	(SAI NSC)
335	HDGV - Limited Access Roads	(SAI NSC)
336	HDGV - Rural Roads	(SAI NSC)

TABLE 3. Concluded.

Refueling Loss Emissions (cont.):		
337	HDGV - Suburban Roads	(SAI NSC)
338	HDGV - Urban Roads	(SAI NSC)
339	Off Highway Gasoline vehicles	(SAI NSC)
340	HDDV - Limited Access Roads	(SAI NSC)
341	HDDV - Rural Roads	(SAI NSC)
342	HDDV - Suburban Roads	(SAI NSC)
343	HDDV - Urban Roads	(SAI NSC)
344	Off Highway Diesel Vehicles	(SAI NSC)
Running Loss Emissions:		
427	LDGV - Limited Access Roads	(SAI NSC)
428	LDGV - Rural Roads	(SAI NSC)
429	LDGV - Suburban Roads	(SAI NSC)
430	LDGV - Urban Roads	(SAI NSC)
431	MDGV - Limited Access Roads	(SAI NSC)
432	MDGV - Rural Roads	(SAI NSC)
433	MDGV - Suburban Roads	(SAI NSC)
434	MDGV - Urban Roads	(SAI NSC)
435	HDGV - Limited Access Roads	(SAI NSC)
436	HDGV - Rural Roads	(SAI NSC)
437	HDGV - Suburban Roads	(SAI NSC)
438	HDGV - Urban Roads	(SAI NSC)
439	Off Highway Gasoline vehicles	(SAI NSC)
440	HDDV - Limited Access Roads	(SAI NSC)
441	HDDV - Rural Roads	(SAI NSC)
442	HDDV - Suburban Roads	(SAI NSC)
443	HDDV - Urban Roads	(SAI NSC)
444	Off Highway Diesel Vehicles	(SAI NSC)

employed in this disaggregation. Commonly used indicators include population and/or housing, landuse categories (e.g., urban, agricultural, or rangeland), and link information (locations of major roadways, shipping channels, airports, railways, etc.). Distribution of the surrogates used to spatially allocate emissions must be determined for the entire modeling region by grid cell. Landuse by grid cell can be estimated using maps available from local planning agencies; USGS maps are often useful for locating such sources as railways and airports.

Spatial surrogate indicator distributions should also be estimated for future year inventories which will be developed from the baseline inventory. Future year spatial surrogate distributions should reflect anticipated changes in landuse, requiring coordination with local planning agencies.

For compatibility with EPS, spatial surrogate distributions should be tabulated as fractions of the county total for that surrogate for each grid cell associated with the county. Grid cells can be identified by either UTMs or (I,J) coordinates, although the final gridded surrogate field used as input to the EPS module GRDEMS must be referenced by (I,J) coordinates. If the exact extent of the modeling domain has yet to be determined when the spatial surrogate distribution-data is collected, identifying grid cells by UTM coordinates provides a more versatile data base. Spatial surrogate distribution can then be determined over a larger region than is likely to be modeled; the final gridded surrogate field can easily be extracted from this data base, and UTM coordinates converted to (I,J) modeling coordinates with minimal effort. The modeling domain, however, should ideally be identified prior to collecting any data in order to minimize resource requirements. All spatial surrogate distribution data except for link data should be included in a single file; separate files will be maintained for base year and future year distributions.

Link data is generally digitized from maps; features that can be included in the link file include major roadways, railways, airports, and shipping channels. To be compatible with EPS, individual link segments must end at county borders. Currently, EPS does not support spatial allocation based on weighted travel by link; instead, all emissions from sources assigned to a given link type within a county are distributed based on the fraction of total county distance for that link type within each particular grid cell.

Modifications to the link-allocation routine in the GRDEMS module could be implemented to account for weighted travel distributions by link. Alternatively, link segments could be artificially weighted by grid cell by adding "dummy" links of a length necessary to produce the desired distribution within each cell. The UAM assumes an equal allocation of non-elevated emissions over the entire grid cell, so the actual location of a link within a grid cell will not affect the location of emissions in the final modeling inventory.

In particular, link data generated for distribution of on-road motor vehicle emissions should ideally incorporate different travel weightings by link which are representative of the day of week being modeled. Separate link files would then need to be maintained for each day of multiday modeling episodes.

IV. TEMPORAL ADJUSTMENT AND DISTRIBUTION OF EMISSIONS

Annual emission estimates must be adjusted to reflect seasonal, weekday/weekend, and diurnal variations in either activity levels or emission factors. The default temporal distribution profiles and factors by source category provided with EPS may not be representative of actual patterns for a given region. For example, shorter growing seasons in some portions of the country may result in a different monthly profile for emissions from agricultural operations than would be appropriate for a warmer region. Similarly, emission factors used to estimate evaporative emissions from solvent use, gasoline marketing, and other activities can be strongly temperature-dependent. The effect of regional ambient meteorological conditions on emission levels may accordingly result in seasonal distribution profiles which differ significantly from the EPS defaults.

Ideally, locale-specific temporal variation data should be collected for all sources which contribute significantly to the inventory. Monthly fractions of annual levels are preferable to seasonal fractions, but either can be used to construct the monthly activity profile required by GRDEMS. In addition to seasonal profiles, regional weekday/weekend activity levels and diurnal variation by source category can be determined through special surveys or estimated using engineering judgment.

Locale-specific temporal data can be incorporated into the emission inventory in several ways, either by modifying EPS input files or by developing supplemental software. Locale-specific temporal distribution factors by area source category can usually be incorporated into the modeling inventory without developing supplemental software. Monthly fractions of annual activity, weekly profile codes which identify typical activity profiles by day of week, and diurnal profile codes are assigned by source category in an input to the GRDEMS module. This file should be edited so that temporal profile assignments reflect locally applicable rather than default variations in activity. Diurnal and weekday codes and profiles currently defined in EPS inputs are shown in Tables 4 and 5. If none of the existing profiles match the desired temporal distribution for a given source category, additional profiles can be created. All new profiles must be added to the files defining weekday and diurnal distribution profiles used as inputs to the EPS module CENTEMS.

Alternatively, diurnal variations in emissions can be incorporated directly into the modeling inventory. The day-specific modeling emission record format (merf), shown in Table 6, allows the user to specify the hourly fractions used to diurnally allocate total daily emissions. Unusual diurnal profiles not currently defined in the temporal

TABLE 4. Diurnal variation codes used in the emissions preprocessor system.

Code	Emissions Contribution by Hour (0-23)																							Daily
1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
3	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
4	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
5	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
6	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
7	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
8	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
9	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
10	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
11	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
12	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	8
13	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
14	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
15	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
16	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
17	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
18	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
19	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
25																									
26																									
27																									
28																									
29																									
30																									
31	3	1	1	1	1	1	1	5	5	5	5	5	5	5	5	5	5	10	10	10	10	7	7	3	116
32																									
33	2	2	2	2	2	2	2	10	10	6	6	5	5	5	5	5	5	5	5	10	10	10	10	2	128
34	0	8	8	8	8	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72
35	10	1	1	1	1	1	1	8	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	182

continued

TABLE 4. Concluded.

Code	Emissions Contribution by Hour (0-23)																							Daily
36																								
37	0	0	0	0	0	1	3	6	9	10	10	10	10	10	10	10	10	9	6	3	1	0	0	0	118
38	0	0	0	0	0	2	6	6	2	2	1	2	4	4	2	1	1	3	10	8	7	6	1	0	68
39																								
40	0	0	0	0	2	3	4	4	4	4	4	4	3	3	2	2	1	1	0	0	0	0	0	0	41
41	0	0	0	0	0	0	18	59	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	37	35	0	0	0	0	0	0	100
43	14	11	3	2	4	19	27	0	50	78	88	94	99	93	99	3	3	39	87	0	50	44	33	14	999
44	3	8	2	1	1	4	12	36	48	54	70	72	71	68	75	76	84	78	65	56	42	35	25	8	999
45																								
46																								
47																								
48																								
49																								
50	1	1	1	1	1	1	6	10	6	5	5	5	5	5	5	6	10	8	6	4	1	1	1	1	96
51	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	6
52	0	0	0	0	0	1	6	10	10	10	10	10	6	3	3	3	3	4	4	0	0	0	0	0	83
53	0	0	0	0	0	0	0	2	2	2	2	2	0	1	0	0	0	0	0	0	0	0	0	0	11
54																								
55	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	22
56	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
57	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	21
58	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	19
59	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	20
60	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	12
61	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
62	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	10
63	0	0	0	0	0	0	0	[illegible]	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	11
64	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
65	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	9
66	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	13
67	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	14
68	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	15
69	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	7

TABLE 5. Weekday variation codes used in the emissions preprocessor system.

Code	Emissions contribution by (Mon-Sun)	Total Days
1	1 1 1 1 1 0 0	5
2	0 0 0 0 0 1 1	2
3	1 1 1 1 1 0 0	5
4	1 1 1 1 1 0 0	5
5	1 1 1 1 1 0 0	5
6	1 1 1 1 1 1 0	6
7	1 1 1 1 1 1 1	7
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21	1 1 1 1 1 2 2	9
22	10 10 10 10 10 7 4	61
23	5 5 5 5 5 4 4	33

TABLE 6. Day-specific modeling emissions record format (merf).

Line	Variable	Columns	Type	Description
1*	ISRG	1-3	I	Gridded surrogate code (not used, skipped)
	IFIP	4-8	I	FIPS state/county code (not used, skipped)
	SIC	9-12	R	Either Source Industrial Classification or NAPAP Source Category code
	PS	13-20	A	Either Standard Classification Code or NAPAP Source Category code
	ICL	21-23	I	I coordinate of grid cell
	JCL	24-26	I	J coordinate of grid cell
	IYR	27-28	I	Year, two digits (e.g., 89 for 1989)
	IDYCOD	29-30	I	Diurnal variation code[1]
	IWKCOD	31-32	I	Weekday variation code[2]
	FID	33-41	A	Facility ID (0 or blank for area sources)
	FST	42-46	A	Stack ID (0 or blank for area sources)
	FCNTY	47-52	I	AEROS state/county code
		53-56	-	(Not used, skipped)
	VMNTH	57-116	R	Array of 12 hourly factors[3]
	CO	117-126	R	CO episode emissions (kg/day)
	CNO	127-136	R	NO_x episode emissions (kg/day)
	SOX	137-146	R	SO_x episode emissions (kg/day)
	THC	147-156	R	TOC episode emissions (kg/day)
	PM	157-166	R	PM episode emissions (kg/day)
		167-168	-	(Not used, skipped)
	SLBL	169-175	A	Scenario label (not used, skipped)

* Either -1 or -2, corresponding to the first 12 hours of the day or the second 12 hours of the day, respectively.

2 Always equal to 0 in day-specific merf.

3 Factors used to allocate daily emissions to hours of day; correspond to first 12 hours of day if IDYCOD = -1 and second 12 hours of day if IDYCOD = -2.

input files to EPS can thus easily be accommodated; this format also supports the inclusion of hourly episode-specific emissions data into the modeling inventory. Table 7 shows the standard merf for comparison. Note that in the day-specific merf, emissions reflect episodic levels; the standard merf contains annual average daily emissions.

The day-specific merf is especially useful for incorporating source- or stack-specific operating information or episodic emissions into the modeling inventory. Day-specific merf records must currently be generated outside of EPS; the CENTEMS module, however, accepts both standard and day-specific merf input files.

V. MOBILE SOURCE PARAMETERS

Since EPS was originally designed for use with the NAPAP inventory, mobile source emissions are assumed to be annual, county-level composite emissions for the following vehicle types and road classes: light duty gasoline vehicles, light duty gasoline trucks, heavy duty gasoline vehicles, and heavy duty gasoline trucks for limited access roadways, rural roadways, suburban, and urban roadways. The EPS module PREGRD disaggregates composite mobile source emissions into exhaust, evaporative, running loss, and refueling components and adjusts emissions from annual average to episodic levels based on regional episodic conditions (e.g., temperature and fuel RVP). The factors used for disaggregation and adjustment are calculated from ratios of MOBILE4 emission factors generated for episodic conditions to MOBILE4 emission factors generated using the annual average inputs used to construct the NAPAP inventory, assuming average speeds of 55 mph for limited access, 45 mph for rural, and 19.6 mph for suburban and urban roadways.

Mobile sources often constitute a significant portion of the urban anthropogenic inventory. Consequently, to minimize uncertainties in the modeling inventory, a mobile source inventory generated specifically for the modeling episode should be used instead of an annual-average inventory whenever feasible. Detailed guidance on construction of mobile source inventories is provided in Procedures for Emission Inventory Preparation. Volume IV: Mobile Sources (EPA, 1989). In short, a traffic model is employed in conjuction with a mobile emission factor model (the recommended emission factor model is EPA's MOBILE4) to estimate mobile source emissions by link. Locale- and episode-specific parameters such as link VMT, average speed by link, and VMT mix and fleet mix by vehicle type should be used to ensure that the mobile source inventory reflects actual episodic conditions as accurately as possible.

MOBILE4 calculates exhaust, evaporative, running loss, and refueling emission factors for eight vehicle types (light duty gasoline automobiles, light duty diesel automobiles, two classes of light duty gasoline trucks, light duty diesel trucks, heavy duty gasoline vehicles, heavy duty diesel vehicles, and motorcycles). Accordingly,

TABLE 7. Standard modeling emissions record format (merf).

Line	Variable	Columns	Type	Description
1+	ISRG	1-3	I	Gridded surrogate code (not used, skipped)
	IFIP	4-8	I	FIPS state/county code (not used, skipped)
	SIC	9-12	R	Either Source Industrial Classification or NAPAP Source Category code
	PS	13-20	A	Either Standard Classification Code or NAPAP Source Category code
	ICL	21-23	I	I coordinate of grid cell
	JCL	24-26	I	J coordinate of grid cell
	IYR	27-28	I	Year, two digits (e.g., 89 for 1989)
	IDYCOD	29-30	I	Diurnal variation code
	IWKCOD	31-32	I	Weekday variation code
	FID	33-41	A	Facility ID (0 or blank for area sources)
	FST	42-46	A	Stack ID (0 or blank for area sources)
	FCNTY	47-52	I	AEROS state/county code
		53-56	-	(Not used, skipped)
	VMNTH	57-116	R	Array of 12 monthly factors
	CO	117-126	R	CO annually averaged emissions (kg/day)
	CNO	127-136	R	NO_x annually averaged emissions (kg/day)
	SOX	137-146	R	SO_x annually averaged emissions (kg/day)
	THC	147-156	R	TOC annually averaged emissions (kg/day)
	PM	157-166	R	PM annually averaged emissions (kg/day)
		167-168	-	(Not used, skipped)
	SLBL	169-175	A	Scenario label (not used, skipped)

use of an episode-specific mobile source inventory may require expanding the area source category designations to include new codes for these additional sources (see Section VII of this memorandum, addressing addition of new source categories, for specific guidance).

If resource limitations prevent construction of an episode-specific mobile source inventory, emission factors from MOBILE4 can be used to generate the ratios used by EPS to adjust an available annual average inventory to episodic conditions. At the minimum, this adjustment will require the following data: maximum and minimum ambient temperatures on the episode day(s), fuel RVP, ASTM volatility class, and detailed identification of any Inspection and Maintenance Programs, Anti-Tampering Programs, or Refueling Loss Control Programs (such as Stage II vapor recovery) currently in effect in the region. Additionally, region-specific data such as VMT mix, annual mileage accrual rates, and registration distributions by vehicle type can be incorporated into the adjustment factors. The values of all parameters used to construct the original annual average inventory must also be identified so that appropriate adjustment ratios can be calculated.

A detailed description of the user-specified inputs for MOBILE4 can be found in the User's Guide to MOBILE4 (Mobile Source Emission Factor Model) (EPA, 1989).

VI. SPECIATION OF VOC EMISSIONS

EPS disaggregates VOC emissions into carbon-bond classes based on a combination of the VOC speciation profiles by source type contained in the Air Emissions Species Manual, Volume I: Volatile Organic Compound Species Profiles (EPA, 1988) and the carbon-bond class assignments by chemical compound from Guidelines for Using OZIPM-4 with CBM-IV or Optional Mechanisms (EPA and SAI, 1986). In some cases, however, source-specific speciated emissions or (less commonly) region-specific speciation profiles by source type may be available. This data can be incorporated into the modeling inventory in several ways.

If region-specific speciation profiles by source type are available, the carbon-bond split associated with that profile code can be modified to reflect the locale-specific data. One of the input files to the EPS module CENTEMS contains all of the information required to modify the carbon-bond split for a given profile, namely weight fractions of specific chemicals (identified by SAROAD code) for each of the EPA VOC speciation profiles and molecular weights and carbon-bond class assignments for each chemical compound. For each profile, the carbon-bond split is expressed in units of (moles of each carbon-bond species)/(gram THC). The carbon-bond split for each profile is a weighted composite combining the carbon-bond class assignments for each chemical compound contained in the profile; it is calculated by summing, over each carbon-bond species (i) and each chemical compound (j) present in the profile, the [(weight fraction of compound j for that profile)/(molecular weight of compound j) • (moles of carbon-bond species i for each mole of compound j)], as shown in Equation 1:

$$\text{for each carbon-bond species } i, \quad \left[\sum_{\substack{\text{each}\\ \text{chemical}\\ \text{compound } j}} \left(\frac{\text{wt frac of } j}{\text{mol wt of } j}\right) \cdot \left(\frac{\text{moles of } i}{\text{mole } j}\right)\right] \tag{1}$$

Modified carbon-bond splits corresponding to redistribution of the weight fraction contributions of the individual chemical compounds can thus be constructed fairly easily. However, difficulties may arise if chemical compounds not present in the file designating carbon-bond class assignments by compound are added to the profile, since carbon-bond distributions for the new chemicals may be unavailable from published literature. An appropriate carbon-bond split must then be determined by someone experienced in both photochemistry and the carbon-bond mechanism.

Locale-specific speciation data are more often available for individual sources than for categories of sources. As these data are collected, each chemical compound in the data base should be identified by a universally recognized standardized code rather than by name alone; the SAROAD designation is especially appropriate, since this is the coding system used to identify chemicals in both EPA publications and EPS input files. Additionally, all other data included in a point source inventory (facility, point, and process identification codes, location, operating schedule information, etc.) should be linked with each emission record to facilitate further processing. EPS does not currently support direct incorporation of pre-speciated emissions by stack into the modeling inventory. Consequently, additional software must be developed to assemble emissions from these sources into a UAM-compatible emissions file. This software must accomplish the following tasks:

- Disaggregate emissions of individual chemicals into carbon-bond species;
- Apply appropriate temporal factors to adjust for seasonal and day-of-week variations;
- Disaggregate emissions by hour of day based on diurnal profiles;
- Distinguish between elevated and low-level sources;
- Create a UAM-compatible emission file containing low-level emissions; and

- Create an elevated point source emission file for input to the UAM elevated point source preprocessor, PTSRCE.*

VII. PROJECTION OF FUTURE YEAR INVENTORIES

Often, future year inventories must be generated for planning purposes or control strategy evaluations. EPS allows the baseline inventory to be "grown" using ratios of future-to-base-year expected activity levels or activity level indicators for general categories of sources. Upper bounds on point source emissions based on maximum future year permittable emission levels may also need to be incorporated into the projected inventory. Bounded emissions projections might also result from process capacity limits. The current EPS will not impose an upper-bound limit on emissions; such processing must occur outside of EPS.

Common indicators used to estimate future year activity levels for source categories include employment by industrial category (the Bureau of Economic Analysis publishes projections for the nation, states, and MSAs), demographic characteristics such as population and housing, and vehicle miles traveled by vehicle type and road type. Appropriate pairing of growth indicators with source categories should be evaluated using engineering judgment.

Alternatively, estimated future year activity levels for individual sources may be obtained through surveying the facilities in question or screening permit applications to determine expected expansions or new construction. This is a resource-intensive approach, so collection of projected future year activity data for individual sources should be limited to the major sources in the region.

EPS projects emissions based on 2-digit SIC code for point sources and NAPAP Source Category Code for area and mobile sources. Projection factors are expressed as a ratio of future-to-base year activity. Source-specific projections (incorporating such information as anticipated shut-downs or construction of additional facilities) must be implemented outside of EPS and then incorporated into the remainder of the inventory. For point sources, it may be desirable to assign growth based on projected fractional increases of industrially zoned land by grid cell instead of assuming that all growth will occur at existing plants. This approach, however, will probably

---

* If source-specific speciated emissions are not available for all elevated stacks within the modeling region, THC emissions from some elevated stacks must be speciated through EPS by source classification code using either EPA or locale-specific VOC speciation profiles. Supplemental software will need to be developed to merge the source-specific and EPS-generated elevated point source emission files before the elevated point source processor can be run.

require the creation of hypothetical point source records; all information associated with a point source record (including process identification codes and stack parameters) must be estimated for each hypothetical record. Additionally, supplemental software or multiple runs of EPS modules may be required if different growth rates are used for sub-regions of the modeling domain.

VIII. INCORPORATION OF ADDITIONAL SOURCE CATEGORIES

For some regions, emission estimates may be available for source types not included in Table 3. Incorporation of additional source categories into the modeling inventory may require minor computer code changes to EPS as well as modifications to input files.

Area source categories may be added to the inventory in one of two ways. If some of the NAPAP categories listed in Table 3 are not applicable to the region in question, their NAPAP source category codes may be reassigned to new types of sources. All temporal profiles and spatial allocation surrogate pairings (used as input to GRDEMS) associated with the reassigned codes must be reviewed and revised if necessary. Additionally, the speciation profiles and reporting category code assignments used by the CENTEMS module (activity code, old inventory category code, process code, and control code) must be reassigned to ensure compatibility with the reassigned NAPAP source category designations.

Alternatively, the user can create new code designations in addition to the categories in Table 3. In this case, the maximum parameters set in each of the EPS modules used to process the area source portion of the inventory (i.e., PREGRD, GRDEMS, and CENTEMS) must be assessed and modified where necessary to ensure that array dimension bounds will not be exceeded because of the additional categories. New spatial allocation surrogate and temporal profile assignments must be made for all new categories; approriate growth indicators must also be selected and all data incorporated into the appropriate input files. Likewise, appropriate speciation profiles and reporting category code assignments must be identified and included in the CENTEMS and POSTEMS inputs.

Disaggregation of mobile source emissions into source categories besides exhaust, evaporative, running, and refueling losses (e.g., hot soak, hot stabilized, cold start, etc.) or inclusion of additional sources (such as motorcycles) requires all of the modifications discussed above for new source category code designations. Additionally, extensive code modifications to the PREGRD module will be necessary, or the functions provided by PREGRD for adjustment of mobile source emissions (discussed in the previous section on mobile source parameters) must be duplicated outside of EPS, perhaps in a supplemental module either parallel or subsequent to PREGRD and prior to GRDEMS.

The addition of point source SIC/SCC combinations not currently included in the input files to CENTEMS requires less effort than inclusion of additional area or mobile source categories. For each new SIC/SCC combination, appropriate reporting category codes must be assigned: the SCC/speciation profile pairings should also be checked if the SCC in the new pair does not appear in any existing SIC/SCC combinations, since the new SCC may not be present in the CENTEMS input file pairing SCCs with speciation profiles.

IX. MULTISTATE AND MULTINATION MODELING DOMAINS

For some areas, the inclusion of all major sources that may affect the urban region requires extending the modeling domain across state or sometimes national borders (namely, Canada and Mexico). In these cases, it is often necessary to obtain emissions data for portions of the domain from other agencies. These data may have to receive special treatment, such as conversion to an EPS-compatible format, before it can be incorporated into the modeling inventory.

A province-level NAPAP inventory has been compiled for Canada; the technical memorandum "Recommended Software and System Upgrades: the UAM Emission Preprocessor System (EPS)" discusses some of the problems encountered in combining emissions estimates from the Canadian and U.S. NAPAP inventories into a single photochemical modeling inventory (SAI, 1990). Specifically, the Canadian inventory employs a different SIC, SCC, and source category coding system that must be cross-referenced with the U.S. designations. Additional problems include the lack of readily available data bases for construction of gridded spatial surrogate fields and speciation of emissions.

Emissions estimates for Mexican sources are likely to be less readily available than Canadian information. Mobile source emission factors for Mexican vehicles may need to be estimated by modifying the fleet distribution and anti-tampering rates used as input to MOBILE4; it may also be desirable to modify the zero mile emission factors and deterioration rates internal to the MOBILE4 code (any modifications to MOBILE4 code should be discussed with, and approved by, the EPA Office of Mobile Sources). The industrial source inventory may need to be generated by hand from available information describing source characterization, location, and activity levels. Special attention should be given to identifying types of control equipment widely employed in the United States but not required in Mexico, which might make U.S. emission factors by source classification inapplicable. Gridded spatial allocation surrogate fields and link files must also be developed to distribute area and mobile source emissions.

Developing the mobile source portion of the photochemical modeling inventory for a multistate modeling domain requires a slightly different procedure than is used for a single-state region. If episodic mobile source emissions are estimated by adjusting an annual average inventory as described in Section V, the MOBILE4 inputs used to estimate each state's mobile source emissions in the annual inventory must be identified and a separate set of mobile source adjustment factors defined for each state.

Similarly, the growth factors used to project future year inventories will probably differ by state. For these reasons, it may be necessary to process each state's contribution to the area and the point source inventory separately through the PREGRD and PREPNT modules. The output merf emission files for each state from these modules can then be merged before further processing. For point sources, however, a separate PREPNT run using dummy growth factors and a combined annual inventory of all point sources within the modeling domain should be made so that a single stack control file (used as input to the CENTEMS module) containing all stacks in the region is generated.

X. BIOGENIC EMISSIONS

In recent years, air quality modelers have begun to recognize that biogenic emissions (naturally occurring emissions from vegetation) can contribute significantly to the total hydrocarbon inventory, even in predominantly urban regions. Some of the chemical species commonly found in biogenic emissions are also quite photochemically reactive (e.g., isoprene). Accordingly, the photochemical modeling inventory should include an estimate of biogenic emissions for completeness.

EPS Version 1.00 does not contain a module for generating biogenic emission inventories; however, EPA's recently developed Biogenic Emission Inventory System (BEIS) is distributed with EPS. This system produces a UAM-formatted biogenic inventory by using a biomass data base (derived from landuse data from the Oak Ridge National Laboratory's Geoecological Data Base) in conjunction with emission factors by forest type (developed by Zimmerman). BEIS provides algorithms for calculating the effects of temperature and light intensity on biogenic emission rates and can accordingly be used to develop a biogenic emission inventory which includes the effects of region-specific hourly temperatures and light intensity. The canopy model utilized in BEIS also requires as input the gridded hourly wind fields used by UAM; these are used to account for varying leaf surface temperatures in different strata of the canopy. Incorporation of additional locale-specific information (such as a more highly resolved landuse data base or emission factors for plant species indigenous to the region) requires modification of the BEIS code.

XI. SUMMARY

This memorandum identifies methods by which locale-specific information can be incorporated into a photochemical modeling emission inventory. Specific topics addressed included the following:

30127 2

- Spatially allocating emissions using distribution surrogates and/or link data;
- Temporally distributing and adjusting emissions;
- Generating or adjusting mobile source inventories using episode-specific parameters;
- Speciating VOC emissions;
- Projecting future year inventories;
- Adding source categories; and
- Incorporating biogenic emissions.

A brief review of the emission inventory input requirements of the Urban Airshed Model and the UAM Emission Preprocessor System Version 1.00 developed for EPA is provided. Additionally, for each of the categories listed above, modification of EPS input files to accommodate locale-specific data and supplemental software requirements are discussed in detail.

REFERENCES

User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System, EPA-450/4-90-007D. U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, June 1990.

User's Guide to MOBILE4, EPA-AA-TEB-89-01, U.S. Environmental Protection Agency, February 1989.

Procedures for Inventory Preparation, Volume IV: Mobile Sources, EPA-450/4-81-026d (Revised), U.S. Environmental Protection Agency, July 1989.

Air Emissions Species Manual, Volume I: Volatile Organic Compound Species Profiles, EPA-450/2-88-003a, U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, April 1988.

H. Hogo and M. W. Gery, Guidelines for Using OZIPM-4 with CBM-IV or Optional Mechanisms, Volume 1, EPA Contract No. 68-02-4136, Systems Applications Incorporated, 1986.

Development of a Biogenic Emissions Inventory System for Regional Scale Air Pollution Models, T. E. Pierce, B. K. Lamb, and A. R. Van Meter, Paper No. 90-94.3, presented at the 83rd Air and Waste Management Association Annual Meeting at Pittsburgh, Pennsylvania, June 1990.

P. Zimmerman, Determination of Emission Rates of Hydrocarbons from Indigenous Species of Vegetation in the Tampa Bay/Petersburg, Florida Area, EPA-904/9-77-028, U.S. Environmental Protection Agency, Atlanta, GA, 1979.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. 450/4-91-014	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Procedures for the Preparation of Emission Inventories for Carbon monoxide and Precursors of Ozone, Vol. II: Emission Inventory Requirements for Photochemical Air Quality Simulation Models	5. REPORT DATE June 1991
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Environmental Protection Agency Office of Air Quality Planning and Standards Technical Support Division (MD-14) Research Triangle Park, NC 27711	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Project Officer - Keith A. Baugues

16. ABSTRACT

This is a companion document to Volume I, which describes procedures for compiling the annual countywide inventory of volatile organic compound (VOC) emissions. Volume II describes procedures for converting the annual countywide emission inventory to the detailed inventory needed for photochemical models. The detailed inventory contains hourly gridded emissions (by species class for VOC and NOx) and CO for the days to be simulated in the photochemical model.

This document is an update to the original, (450/4-79-018), published is 1979.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Emissions Inventory Gridding Hydrocarbons Nitrogen Oxides Photochemical Models Spatial Resolution Temporal Resolution Species Resolution Volatile Organics		

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES 239
	20. SECURITY CLASS *(This page)*	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE