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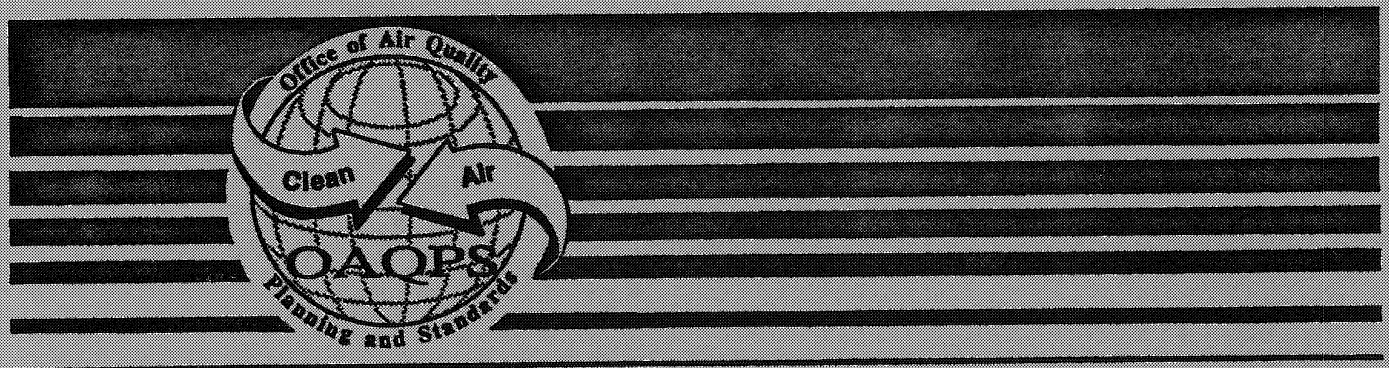
PROCEDURES FOR THE PREPARATION OF EMISSION INVENTORIES FOR CARBON MONOXIDE AND PRECURSORS OF OZONE

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



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

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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 is the second revision of this volume, which updates the versions released in 1979 (EPA-450/4-79-018) and 1991 (EPA-450/4-91-014) 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 from the previous versions as summarized below:

- Inclusion of an additional section containing a brief overview of the Urban Airshed Model (UAM) and the UAM Emissions Preprocessor System, Version 2.0 (EPS 2.0).
- 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 emission estimates by emissions component (e.g., exhaust, evaporative) 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 EPS 2.0.
- Discussion of considerations specific to modeling for CO nonattainment 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: General Guidance for Stationary Sources*, 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 described 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 modeling domain instead of at a county or regional level;

- Emissions must be specified as hourly rather than annual or daily rates. Additionally, annual or seasonal average rates should be adjusted to reflect episodic or day-specific conditions as accurately as possible.

- 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.

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1 INTRODUCTION

1.1 PURPOSE

This document supplements *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I: General Guidance for Stationary Sources. 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 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. 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 described 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 modeling domain instead of at a county or regional level;

- Emissions must be specified as hourly rather than annual or daily rates. Additionally, annual or seasonal average rates should be adjusted to reflect episodic or day-specific conditions as accurately as possible.

- 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, Version 2.0 (EPS 2.0), 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 point, area, mobile, and biogenic sources, including chemical speciation of VOC and NO_x emissions.

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 EPS 2.0 will be enclosed in a gray box, as shown here.

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 the Empirical Kinetic Modeling Approach (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, 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 both CO and ozone nonattainment area emission inventories, consult *Emission Inventory Requirements for CO SIP Nonattainment Areas* and *Emission Inventory Requirements for Ozone SIP Nonattainment Areas* (EPA, 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. Consult EPA guidance on emission inventory projection techniques and on RFP preparation for further information.

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 chapters 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

Under the 1990 Clean Air Act Amendments, air quality analyses using photochemical grid models are required for areas designated as serious, severe, and extreme ozone nonattainment areas and multistate moderate ozone nonattainment areas. 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 existence." Currently, the UAM is the recommended air quality simulation model for use in ozone air quality analyses in the preparation of State Implementation Plans (SIPs) 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 was made available to the public in 1990 as the UAM Emissions Preprocessor System (EPS), version 1.0. Since the passage of the 1990 Clean Air Act Amendments, a growing emphasis on the use of the UAM in regulatory applications has led EPA to fund a series of enhancements to the initial EPS, aimed at improving flexibility, providing a more efficient and user-friendly processing environment, and expanding the capabilities of the system, especially regarding the implementation of proposed control strategies. The enhanced system is called EPS 2.0.

EPS. 2.0 provides the user with expanded capabilities to support the CAAA requirements, conform to EPA emission inventory requirements, and provide a method for evaluating proposed control measures for meeting RFP regulations. Regulatory requirements call for hydrocarbon to be reported as reactive volatile organic compounds, motor vehicle emissions to be adjusted hourly for temperature effects, and all State Implementation Plan emission inventories to be submitted to a central data base (AIRS). EPS. 2.0 has features to process emission inventories that meet these requirements. Further capabilities include processing of a link-based emissions, point-specific speciation, and locale-specific temporal profiles.

The flexibility of EPA 2.0 provides the users with many options for preprocessing their emissions inventory. The design provides the users with (1) a "turn-the-crank" system for generating modeling inventories, and (2) a means for the discriminating user to implement detailed, locally available data such as source-specific speciation, temporal information, and episode specific emissions.

EPS 2.0 consists of a series of FORTRAN modules that perform the intensive data manipulations required to incorporate spatial, temporal, and chemical resolution into an emissions inventory used for photochemical modeling. The modules can be classified into four major components of the system: (1) core EPS modules, (2) input preparation utilities, (3) support utilities to manipulate the internal record format, and (4) reporting utilities.

Before executing EPS 2.0, 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 (Version 4.1 or higher) 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 Manual for the Emissions Preprocessor System 2.0, Part A: Core FORTRAN System* (EPA-450/4-90-007D (R), May 1992), and

- *User's Guide to MOBILE4.1 (Mobile Source Emission Factor Model)* (EPA-AA-TEB-91-01, June 1991) or *User's Guide to MOBILE5*.

3.3.1 EPS 2.0 Core Modules

Figure 3-1 provides an overview of the EPS 2.0 core system. In this figure, the ten core modules have been divided into three categories: data loading modules (PREPNT, PREAM, and LBASE), preprocessing modules (CNTLEM, CHMSPL, TMPRL, RPRTEM, PSTPNT, and GRDEM), and final preprocessing modules (MRGUAM). After data has been loaded into EPS 2.0, the remaining modules (except for MRGUAM, which reads UAM-formatted emissions files) employ a common internal file format, referred to as EMBR ("Emissions Model Binary Record") format. This allows these modules to be executed in any order, with the exception that the PSTPNT and GRDEM modules must be executed last since these two modules produce the UAM-formatted emissions files. (Note that the UAM preprocessor PTSRCE must be executed subsequent to EPS 2.0 to prepare the final UAM elevated point source input file needed for modeling.) Table 3-1 lists the input and output files for each of the core modules.

The ten modules and their primary functions are briefly described below. For a detailed description of EPS 2.0 and its input file formats, see the *User's Guide for the Urban Airshed Model: Volume IV, Part A*.[3]

PREPNT. The PREPNT module is the entry point to EPS 2.0 for point source emissions data. The primary functions of PREPNT are

- identification of sources within the modeling domain;

- initial screening of which sources are to be treated as elevated point sources; and

- reformatting of an emissions inventory generated by the AIRS AFS into EMBR format.

PREPNT reads point source data in AIRS Facility Subsystem (AFS) work file format, including stack parameters, process and geographical identification codes, and emission rates for any or all of the following pollutants: NO_x, VOC (or THC), CO, SO_x, TSP, and PM-10. PREPNT converts the emissions to an average daily rate for the time period of the AFS work file. PREPNT also calculates a plume rise for each stack based on the Briggs effective height calculation (using default

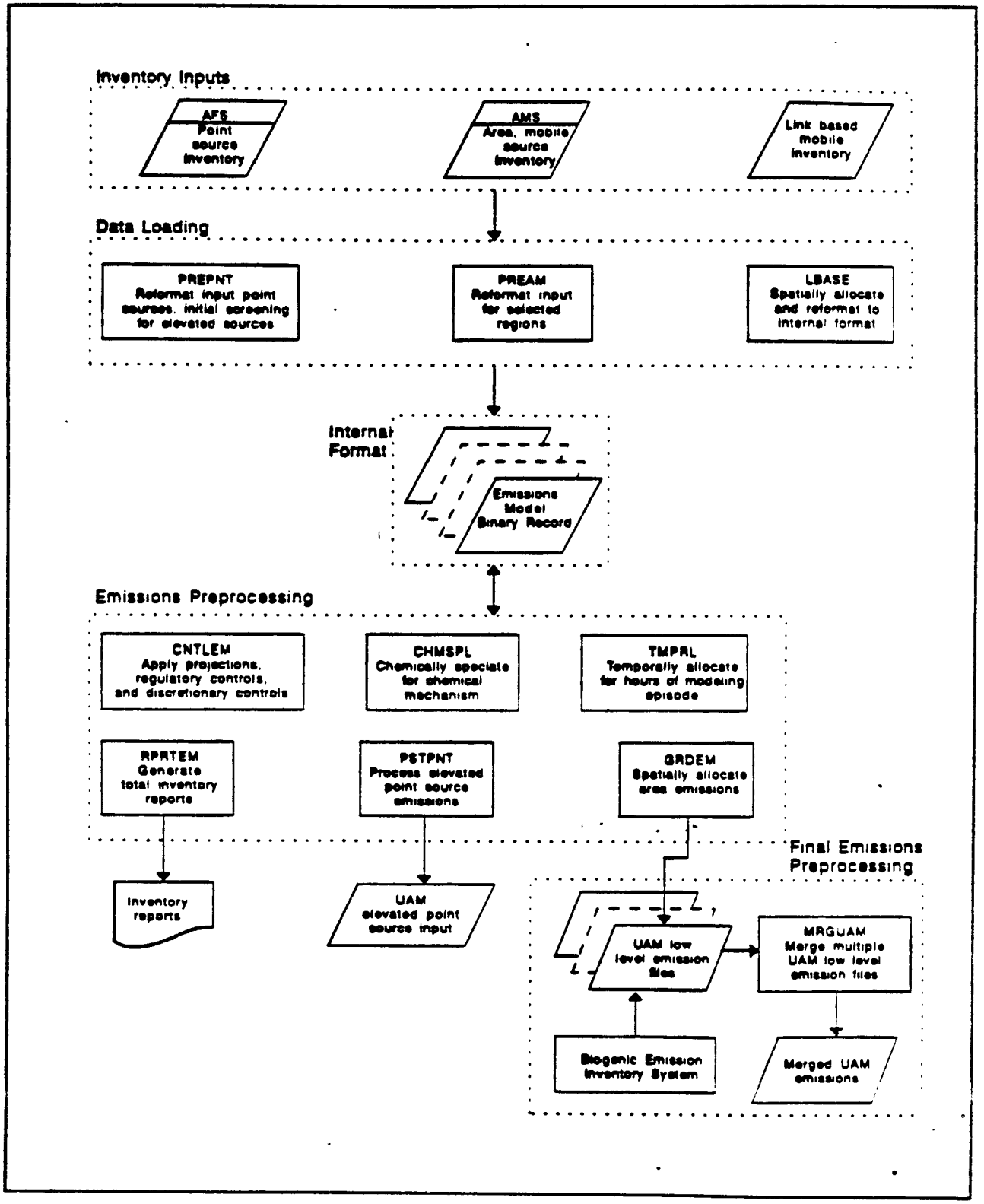


FIGURE 3-1. Overview of the EPS 2.0 core system.

TABLE 3-1. Input and output files for EPS 2.0 core modules.

Module	Input files	Output files
PREPNT	USERIN: /PREPNT/, /UAMREGN/, /COUNTY/ AFS work file SCC(ASC)/speciation profiles cross reference	PREPNT message file EMBR point source file stack report error records file (AFS format)
PREAM	USERIN: /PREAM/ *(optional)*, /COUNTY/ AMS work file SCC(ASC)/speciation profiles cross reference MADJIN: /DISAG/	PREAM message file EMBR area source file EMBR motor vehicle file error records file (AMS format)
LBASE	USERIN: /LBASE/, /UAMREGN/, /COUNTY/ link based emissions file SCC(ASC)/speciation profiles cross reference MADJIN: /DISAG/	LBASE message file EMBR motor vehicle file error records file (link based data format)
CNTLEM	USERIN: /CNTLEM/, /COUNTY/ control factors file SCC(ASC)/speciation profiles cross reference SIC/SCC(ASC) reporting codes glossary MADJIN: /MVCNTL/ EMBR file	CNTLEM message file EMBR file EMAR error records file
CHMSPL	USERIN: /CHMSPL/, /EPISODE/ SCC(ASC)/speciation profiles cross reference carbon bond split factors EMBR file	CHMSPL message file EMBR file EMAR error records file
TMPRL	USERIN: /TMPRL/, /EPISODE/ SCC(ASC)/temporal profiles cross reference temporal profiles MADJIN: /MVTMPRL/ *(optional)* EMBR file	TMPRL message file EMBR file EMAR error records file
PSTPNT	USERIN: /PSTPNT/, /EPISODE/, /UAMREGN/ EMBR point source file	PSTPNT message file ASCII elevated point source emissions file
GRDEM	USERIN: /GRDEM/, /EPISODE/, /UAMREGN/ SCC(ASC)/spatial surrogate cross reference gridded spatial surrogates link data *(optional)* EMBR file	GRDEM message file EMBR *or* UAM low level emissions file EMAR error records file
MRGUAM	USERIN: /MRGUAM/ *(optional)*, /EPISODE/ one to ten UAM low level emissions files	MRGUAM message file merged UAM low level emissions file
RPRTEM	RPRTEM user input file SIC/SCC(ASC) reporting codes glossary SCC(ASC)/speciation profiles cross reference reporting code descriptions one to six EMBR files	RPRTEM message file summary report file

source: Reference 3

meteorological parameters representing stable conditions), 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.

PREAM. The PREAM module serves as the entry point to EPS 2.0 for area and non-link based mobile source emissions data. The primary functions of the PREAM module are

- separation of area and onroad motor vehicle emissions data into two files;
- disaggregation of onroad motor vehicle emissions into emissions components; and
- reformatting of an emission inventory generated by the AIRS Area and Mobile Subsystem (AMS) into EMBR format.

PREAM reads the AMS work file, separates the data into onroad motor vehicle sources and area sources (which include offroad mobile sources), converts the emissions to an average daily rate for the time period of the AMS work file, and writes the output records to the appropriate EMBR files. For motor vehicle sources, PREAM also disaggregates total emissions into exhaust, evaporative, running loss, and resting loss components. In the event that link-based emissions data are available and have been processed by the LBASE module, PREAM will subtract the link-based emissions totals (provided by the user) from the county totals before processing the AMS record.

LBASE. The LBASE module incorporates link-based emissions estimates into the modeling inventory; like the PREPNT and PREAM modules, LBASE serves as an entry point for the EPS 2.0 system. The primary functions of the LBASE module are

- identification of links within the modeling domain;
- spatial allocation of link-based emissions to grid cells;
- disaggregation of motor vehicle emissions into exhaust, evaporative, running loss, and resting loss components; and
- reformatting of link-based emissions estimates into the EMBR format.

LBASE reads the link-based emissions data, processes the data for each link, and writes the processed data to an EMBR file. The data may be hourly, seasonal, or annual average emission rates, and may include any or all of the following pollutants: NO_x, VOC, CO, SO_x, TSP, and PM-10. LBASE spatially allocates the link-based emissions by computing the fraction of the total link length contained in each cell traversed by the link. Onroad motor vehicle emissions are also separated into exhaust, evaporative, and running loss components; this disaggregation is required for correct Carbon Bond Mechanism speciation of the emissions by the CHMSPL module.

CNTLEM. The CNTLEM module allows the user to simulate the effects of various control strategies on the emissions contained in the inventory. This module provides the user with methods for

- projecting (or backcasting) a base year emission inventory to represent emissions levels for another year, based on user-specified projection factors for changes in activity levels by source category;

- assessing the effects of mandated regulatory controls (e.g., Maximum or Reasonably Available Control Technologies, Control Technique Guideline controls, or allowable emissions limits) on projection year inventories;

- assessing and comparing the effects on emissions levels (and consequently air quality) of different control strategies under consideration.

CNTLEM may be executed at any stage of processing, but it is recommended as the first step after the input inventory has been loaded into EMBR format (i.e., immediately after running PREPNT, PREAM, or LBASE). If the input EMBR file has been chemically speciated (using the CHMSPL module), CNTLEM will apply control and projection factors to the appropriate carbon bond species based on the criteria pollutant species from which each carbon bond species was derived.

Each record of the AFS and AMS work files from AIRS contains primary control equipment code, control efficiency factor, rule effectiveness factor, and rule penetration factor fields; this information is maintained in the EMBR files. CNTLEM assumes that the effects of existing control equipment have been included in the emissions estimates in the input AFS and AMS work files (in other words, that the emissions represent controlled levels if control data is present for that source). All new controls are assumed to represent replacement technologies.

CNTLEM will apply the following types of projection and control factors, which must be specified by the user in the control factors input file:

- Control Technique Guideline (CTG) controls;

- Maximum Achievable Control Technology (MACT) and non-CTG Reasonably Available Control Technology (RACT) controls;

- projection factors for changes in activity levels;

- onroad motor vehicle controls (and fleet turnover effects for projection inventories);

- other source- or source category-specific controls;

- allowable emissions limits; and

- discretionary control strategy controls (by source category, state or county FIPS, subregion code, and user-specified subgrid, and by control strategy code type: activity, control, pod, and speciation profile)

CHMSPL. The CHMSPL module allows the user to introduce the degree of chemical resolution required by the UAM into the modeling inventory. The primary functions of CHMSPL are

- to disaggregate criteria pollutant emissions into the chemical species used in the Carbon Bond IV (CB-IV) mechanism employed by the UAM; and

- to create a chemically speciated EMBR file for further processing by any of the other EPS 2.0 modules (excluding PREPNT, PREAM, and LBASE).

CHMSPL determines an appropriate speciation profile code based on the SCC code on the EMBR record; the speciation profile code determines the "split factors" for that particular profile. The split factors are multiplicative factors for converting grams of criteria pollutant emissions into moles of the Carbon Bond Mechanism Version IV (CBM-IV) chemical species employed by the UAM. The user may specify which carbon bond species will be generated for the UAM modeling application. CHMSPL then applies the split factors to the emissions for each data record in the input EMBR file and writes the speciated emissions for each of the selected species to an output emissions file, also in EMBR format.

TMPRL. The TMPRL module allows the user to introduce the degree of temporal resolution (i.e., hourly) required for the modeling inventory by the UAM. The primary functions of TMPRL are to

- adjust annual or seasonal average emissions to episodic levels;

- apply hourly temperature adjustments to onroad motor vehicle emissions;

- allocate emissions to the hours of the modeling episode; and

- generate an EMBR file containing hourly emissions data.

If the input EMBR file contains average daily emissions derived from annual data or average daily emissions for a specified period, these are first adjusted by applying a yearly profile to determine emissions levels for the episode month. The emissions are then adjusted for the day of week (Monday-Sunday) of the modeling episode based on weekly variations in activity levels. Finally, the episode-adjusted daily emissions are temporally allocated to each hour using a diurnal variation profile.

The Source Classification Code (SCC) for point sources or Area Source Category (ASC) code code for area and mobile sources from each input emissions record is cross-referenced to a monthly, day of week, and diurnal profile code which determines the temporal profiles applied to the emissions; the codes currently defined in EPS 2.0 system input and glossary files are shown in Appendix C. To

facilitate implementation of source- or geographical region-specific temporal profiles, the first three fields of each record in the cross-reference file allow the user to also specify FIPS state and county codes, plant identification codes, and AFS stack identification codes for which the temporal profile should be applied. For each input EMBR record, TMPRL searches the cross-reference file to determine the assigned temporal profiles for the FIPS state/county codes, facility identification codes, and/or SCC(ASC) code combination most closely matching the input EMBR record.

PSTPNT. In addition to a low-level emissions file, the UAM requires a separate file containing elevated source emissions data. Elevated source data must be processed through the UAM preprocessor PTSRCE to create the binary file used by the UAM (the user will find a complete description of the PTSRCE preprocessor in Volume II of EPA's *User's Guide for the Urban Airshed Model*). Accordingly, the EPS 2.0 core system includes the PSTPNT module, whose primary functions are

- to create the ASCII input file for the UAM PTSRCE preprocessor; and
- to provide the user with tabular summaries of elevated source emissions to assist in quality control tracking.

Since the file of elevated source emissions data created by PSTPNT is intended for input directly to the UAM PTSRCE preprocessor, PSTPNT must be executed after all other processing of the point source data (in other words, PSTPNT should be the last module run for the point source emissions data). PSTPNT reads the EMBR file to obtain the individual stack parameters and hourly emissions data for each source which must be included in the PTSRCE input file. Only those EMBR records which were assigned a record type of "E" (for "elevated") by the PREPNT module are processed and written to the PTSRCE input file.

GRDEM. The GRDEM module allows the user to spatially allocate emissions to the grid cells of the modeling domain. The GRDEM module will

- spatially allocate area and mobile sources based on a combination of gridded spatial surrogates and (optional) link data;
- assign low-level point source emissions to grid cells based on source location; and
- create either a gridded EMBR or UAM-format low-level emissions file.

For area sources, GRDEM spatially allocates regionally-aggregated emissions totals (e.g., county-level or subregion-level emissions) by source category based on the spatial allocation surrogate for that source category, as specified in the SCC(ASC)/gridded surrogate cross-reference file. If digitized link data are available for some categories (e.g., light-duty automobiles on limited access roadways, railroad locomotives, shipping vessels), GRDEM will determine the cells traversed by each link and allocate emissions for that source category accordingly. Alternatively, the user may specify that emissions from these sources be allocated based on a gridded spatial allocation surrogate. (Note the

distinction between link-based emissions, which are processed by the LBASE module and include the effects of varying activity levels for each link, and spatial allocation of emissions using link data, in which county-level emissions are allocated evenly along all links of that type within the county based solely on the length of the link). For low-level point sources, GRDEM assigns emissions to grid cells based on the UTM coordinates of the source.

GRDEM will produce a low-level gridded emissions file in either EMBR format or the format used by the UAM. If the UAM format is chosen, the input EMBR file must have already been processed through the TMPRL and CHMSPL modules to provide the hourly and chemical resolution required by the UAM.

MRGUAM. Different types of emissions data (e.g., point, area, mobile, biogenic) can be processed separately through EPS 2.0 to facilitate both control strategy analysis and quality control tracking. Consequently, the EPS 2.0 core system includes a module for merging multiple emissions files into one file for modeling. The MRGUAM module will

- combine the low-level emissions data from up to 10 UAM-format files into a single file; and
- apply domain-wide, across-the-board multiplicative factors by Carbon Bond Mechanism (CBM) species for any (or all) of the input emissions files.

This second function permits the user to easily create emissions inventories for use in "control sensitivity" applications of the UAM. As discussed in Section 2.4, this type of UAM application is designed to estimate the overall amount of emissions reductions required to produce a desired change in ozone concentrations. Control sensitivity applications should not be confused with control strategy applications, which attempt to simulate as accurately as possible the effects of a specific set of control measures applied at the individual source level.

Although different emissions files used in the same UAM application must all be appropriate to the region and time period being modeled, they may contain different CBM species. Most UAM low-level emissions files will have been created by the GRDEM module, with the notable exception of the biogenic emissions file (which may be created using EPA's UAM Biogenic Emissions Inventory System; refer to Chapter 8). MRGUAM will accept as input any UAM-ready low level emissions file, regardless of its origin. It sums the emissions from all of the input emissions files, by hour, grid cell, and CBM species, and writes the sum to a single file.

RPRTEM. The RPRTEM module summarizes emissions information in a form that facilitates comparative analysis of various control strategies, as well as information useful for quality control tracking. RPRTEM allows the user to create

- reports of total emissions from up to six EMBR files; and
- summaries of the types of data (file type, included species, etc.) included in each input EMBR file.

RPRTEM will produce tabular reports of emission totals by species for different groupings of emission sources. Sources can be grouped according to activity, process, control strategy, pod, or speciation profile codes; these codes are defined in Appendix C. The user also has the option to generate output tables by criteria pollutant, CBM species and selected counties or subregion. The user should select the most applicable reporting category for the purposes for which the summary output will be used.

Since RPRTEM reads EMBR files, it can be run at any stage of inventory processing after the entry modules (PREPNT, PREAM, and optionally LBASE) have been executed. This flexibility allows the user to immediately assess the effects of a particular step in inventory processing on total emissions. RPRTEM reads each record of the EMBR file and then looks up the appropriate reporting codes from the SIC/SCC (ASC) reporting code glossary and cross-reference files based on the SIC and SCC(ASC) codes specified in the EMBR record. If the SIC/SCC code pair for a particular EMBR record is not included in the glossary, RPRTEM writes an appropriate message to a message file and the reporting code is set to the default "miscellaneous" category.

3.3.2 EPS 2.0 Utilities

EPS 2.0 includes various support utilities for (1) generating input files required by EPS 2.0 core modules, (2) manipulating the internal EMBR file structure, and (3) generating reports for quality control. Figures 3-2 and 3-3 show the relationship of the input file preparation utilities and other support utilities to the core EPS 2.0 system. The principle functions of the EPS 2.0 utility modules are listed below:

BEAFAC Produce projection factors for point and area sources (used by CNTLEM).

EMSCVT Create or update the SCC(ASC)/speciation profiles cross reference file (required by PREPNT, PREAM, LBASE, CNTLEM, CHMSPL, and RPRTEM) and the carbon bond split factors file (read by CHMSPL).

MKGLOS Create the direct access reporting code glossary file used by CNTLEM and RPRTEM.

MVADJ Prepare the MADJIN motor vehicle adjustment factors file used by PREAM, LBASE, CNTLEM, and TMPRL

TMPFAC Create or update the SCC(ASC)/temporal profiles cross reference file and temporal profiles definition file required by TMPRL

QCEMBR Provide tabular summaries of the emissions data to augment the reports written by each EPS 2.0 module. (The RPRTEM module also serves as a report utility, creating summary reports of emissions totals for specified reporting categories.)

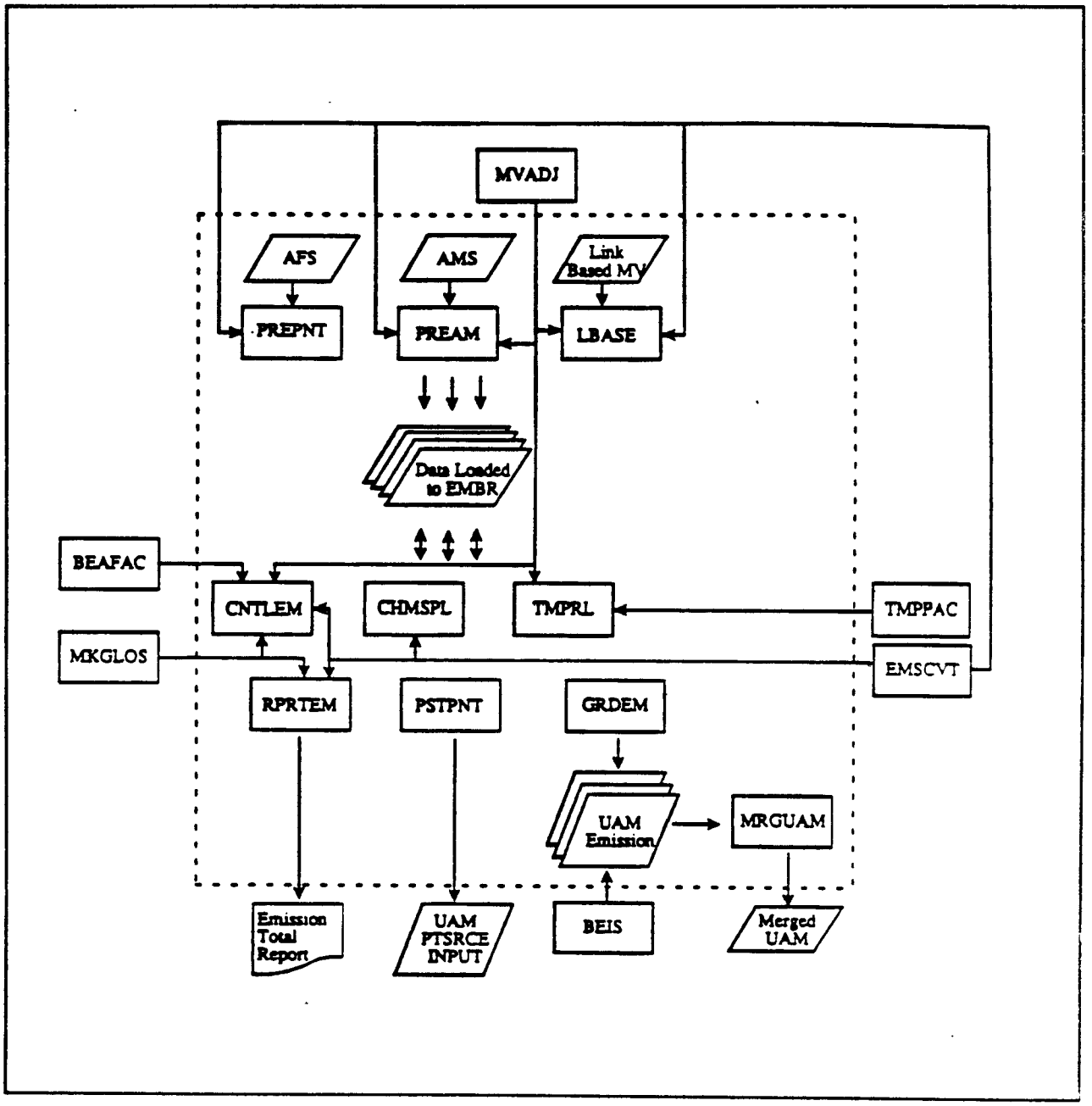


FIGURE 3-2. EPS 2.0 input file preparation utilities.

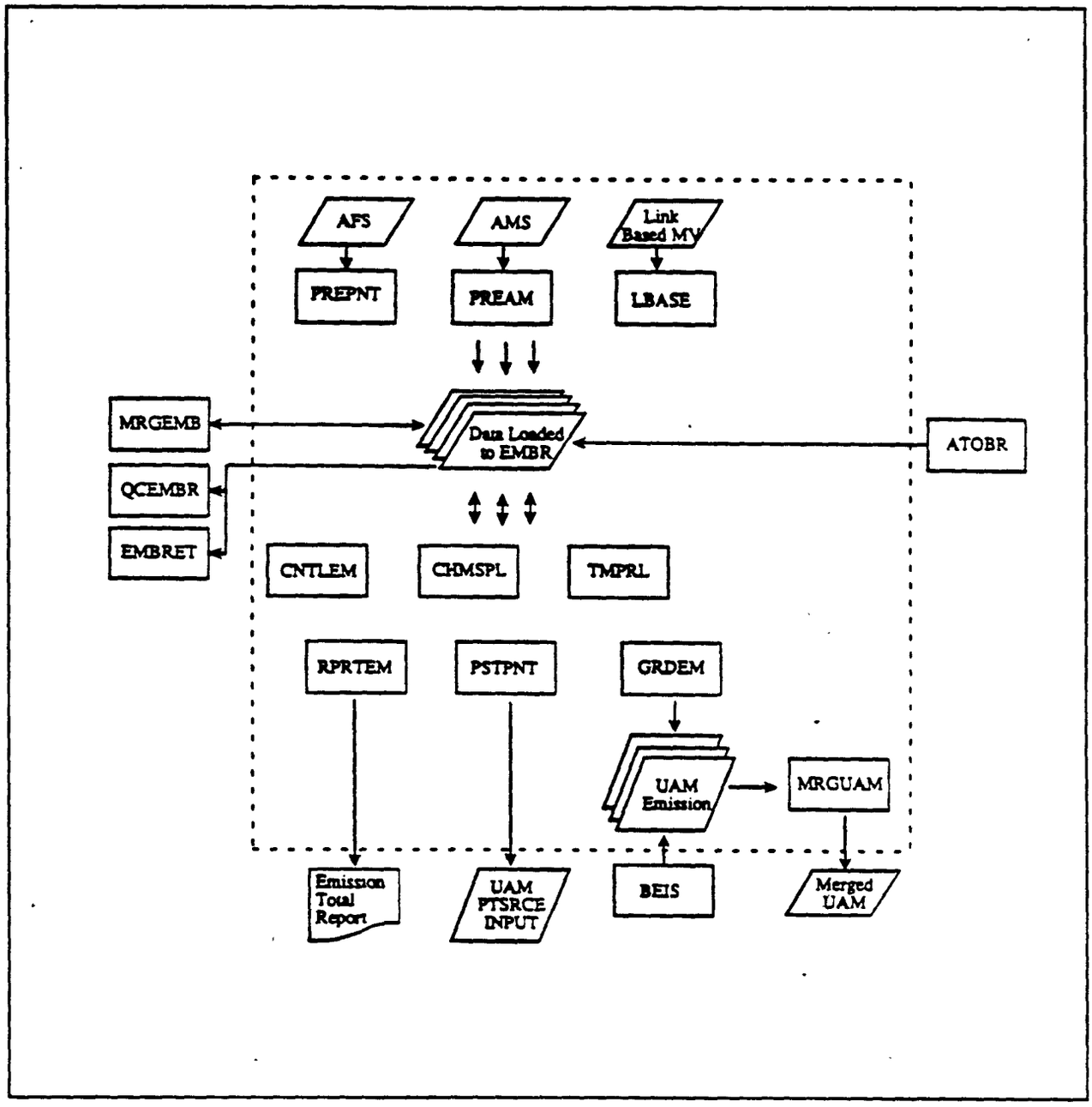


FIGURE 3-3. EPS 2.0 support and reporting utilities.

EMBRET Convert the machine-dependent binary EMBR files to ASCII format for transfer to other systems or modification using an ASCII test editor; will also extract selected records based on user-specified criteria. The ASCII file produced by EMBRET is in EMAR ("Emissions Modeling ASCII Record") format.

ATOBR Convert an ASCII EMAR file to binary EMBR format.

MRGEMB Merge two EMBR files into a single file.

3.3.3 EPS 2.0 Input Requirements

The EPS 2.0 system requires a variety of input data, which can be classified into five categories: emissions data, system default parameters, region-specific data, episode-specific data, and optional data.

Emissions Data. The user must supply the input emission inventory data that the EPS 2.0 requires to process the modeling inventory. Before processing the emission data, the user should confirm that the original inventory data that will be input to EPS 2.0 is appropriate for the purposes of the modeling application. For example, a modeling inventory to be used for model performance evaluation should reflect actual emission rates for the year of the episode. Accordingly, it would be inconsistent to prepare the validation inventory by projecting (or backcasting) an inventory containing allowable emission rates.

EPS 2.0 requires emissions data to be input as two distinct files: point sources and area sources. The point source data must include physical stack parameters and data describing operational schedules as well as total emissions. The area source emissions file should include small stationary sources not included in the point source data file, and both offroad and onroad motor vehicles. In order to properly process the onroad motor vehicle portion of the inventory, the user must also be able to recreate the MOBILE 4.1 mobile source emission factor model runs (i.e., identify the values of the MOBILE 4.1 input parameters) that produced the emissions factors used for estimating onroad motor vehicle emissions in the input data file.

As stated above, the user must supply the emission inventory data for the EPS 2.0 system. These data may either be retrieved from the AIRS system or developed independently by the user; in either case the emissions data files must be formatted according to the AIRS Facility Subsystem (AFS) work file format (for point source data) and the AIRS Area and Mobile Subsystem (AMS) work file format (for area and mobile source data).

The AFS work file contains the point source data required by EPS 2.0 to process this portion of the inventory. The information in the AFS work file can be divided into seven types: inventory description, geographical, source identification, stack characterization, operating schedule information, control technology description, and emissions. Table 3-2 lists the individual data items contained in the AFS work file for each of these seven categories. Certain data fields must contain

TABLE 3-2. Types of data included on each record in the AFS work file. Arrows indicate fields that must contain valid data for use in EPS 2.0. Missing data in other fields will be replaced with default values or ignored.

Inventory Description Data

Inventory type as retrieved from AIRS:
- Adjusted
- Base
- RFP
- Modeling

Projection year

Base year

▷ Emissions type:
- Actual
- Allowable based on activity level limit
- Allowable based on emission factor limit
- Allowable based on both activity level and emission factor limits
- Allowable based on total emissions
- Projected with base year controls
- Projected with new controls
- Allowable with base year controls
- Allowable with new controls

▷ Inventory period:
- Annual
- Typical peak ozone season day
- Typical peak CO season day
- Other specified interval

▷ Period starting and ending dates and times

Geographical Data

▷ FIPS state and county codes

Subregion code (FIPS city code) (optional)

▷ Source location (geodesic or UTMs)

▷ UTM zone (only required if source location is specified in UTM coordinates)

Source Identification Data

▷ Plant identification code

▷ Stack number

Point identification code

Segment number

▷ Standard Industrial Classification Code

▷ Source Classification Code

Stack Characterization Data

Height

Diameter

Exit gas temperature

Exit gas velocity

Operating Schedule Information

Seasonal percentages of annual throughput

Hours per day in operation

Days per week in operation

Hours/year in operation

Start hour (optional)

Control Technology Description

Primary control equipment code

Combined control effectiveness

Rule effectiveness

Rule penetration (not used for point sources)

Emissions Data

▷ AIRS pollutant code (SAROAD)

▷ Emissions for specified pollutant

source: Reference 3

valid data for use in EPS 2.0 (denoted in the table with an arrow, ▷). Although missing data in other fields will be replaced with default values, the resultant modeling emission inventory will be less accurately resolved, which will in turn affect the quality of the UAM modeling results.

Table 3-3 lists the data items contained in the AMS work file for area and mobile sources. The data in this file can be divided into six categories: inventory description, geographical, source identification, control technology description, and emissions. Data fields that must contain valid data for use in EPS 2.0 are denoted with an arrow (▷).

System Default Parameters. EPS 2.0 comes with a set of files containing default inputs for certain data, which are intended to provide the user with an initial EPS setup. These files include:

- Speciation profiles for chemically allocating the emissions to the carbon bond species used by the UAM (derived from data in EPA's *Air Emissions Speciation Manual*);
- Default speciation profile code assignments by Source Classification Code (SCC) and Area Source Category (ASC) code;
- Default reporting code assignments (process, activity, control, process, and pod) by SIC/SCC(ASC);
- Default reporting code descriptions;
- National average temporal allocation profiles;
- Default temporal profile code assignments by SCC(ASC); and
- Economic and demographic projection data for developing projection factors (from the Bureau of Economic Analysis).

In the absence of source- or region-specific data, the default speciation profiles and speciation profile assignments and BEA projection data represent EPA-preferred data sources for speciation and projection data, respectively. Likewise, the default reporting code assignments will prove adequate for most EPS 2.0 applications. The user should review all default inputs for appropriateness for each application.

3.3.4 EPS 2.0 Interface and Emission Display System

EPS 2.0 includes an optional interface and display system to assist the user in setting up an EPS 2.0 application and analyzing the modeling emissions data base created with EPS 2.0. The EPS Interface is composed of two modules: the Setup module and the Graphics module. The Setup module provides a user-friendly environment for creating or modifying several of the input files required to

TABLE 3-3. Types of data included on each record in the AMS work file for Area and Mobile Sources. Arrows indicate fields that must contain valid data for use in EPS 2.0. Missing data in other fields will be replaced with default values or ignored.

Inventory Description Data

Inventory type as retrieved from AIRS:
- Adjusted
- Base
- RFP
- Modeling

Projection year

Base year

▷ Emissions type:
- Actual
- Allowable based on activity level limit
- Allowable based on emission factor limit
- Allowable based on both activity level and emission factor limits
- Allowable based on total emissions
- Projected with base year controls
- Projected with new controls
- Allowable with base year controls
- Allowable with new controls

▷ Inventory period:
- Annual
- Typical peak ozone season day
- Typical peak CO season day
- Other specified interval

Period starting and ending dates and times

Geographical Data

▷ FIPS state and county codes

Subregion code (FIPS city code) (optional)

Source Identification Data

▷ Area Source Category code

Operating Schedule Information

Period percentage of annual throughput

Days per week in operation

Weeks per year in operation

Hourly percentages of daily throughput

Weekday adjustment factor

Saturday adjustment factor

Sunday adjustment factor

Control Technology Description

Primary control equipment code

Combined control effectiveness

Rule effectiveness

Rule penetration

Emissions Data

▷ AIRS pollutant code (SAROAD)

▷ Emissions for specified pollutant

source: Reference 3

run EPS 2.0. A series of interactive screens guides the user through the steps necessary to set up user inputs and control factors for an EPS 2.0 application.

The Graphics module provides the user with tools for statistically analyzing the data emission inventory data and graphically displaying the results. The display program supports a variety of statistical, temporal, and spatial graphics (including bar charts, summary tables, time series plots, and shaded tile maps). The user may perform quantitative analysis of emissions using the statistical graphics, which allow the user to compare information for selected chemical species and/or source types for either the entire modeling domain or selected counties within the domain. The temporal graphics allow the user to portray variations in emissions over time; as for the statistical graphics, the user may select chemical species, source types, and counties for which to display hourly variations in emissions. The spatial graphics, while ignoring temporal variations in the data, provide valuable information regarding the spatial distribution and variation in emissions. The user may display either total emissions for all source types for the modeling domain, or domain-wide emissions for a selected source type. The Graphics module supports both EMBR and UAM emissions files formats, although some options (e.g., display emissions for a selected source type) may not be available for UAM low level emissions files, since the UAM format for low level emissions files only specifies emissions by hour, chemical species, and grid cell.

Refer to the *User's Guide for the Urban Airshed Model, Volume IV: User's Manual for the Emissions Preprocessor System 2.0, Part B: Interface and Emission Display System* for information regarding computing requirements, available options, and using the menu-driven screens for the interface and emission display system.

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 2.0, Part A: Core FORTRAN System*, EPA-450/4-90-007D (R), U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, May 1992.

4. *User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System 2.0, Part B: Interface and Emission Display System*, EPA-450/4-90-007D (R), U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, May 1992.

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]

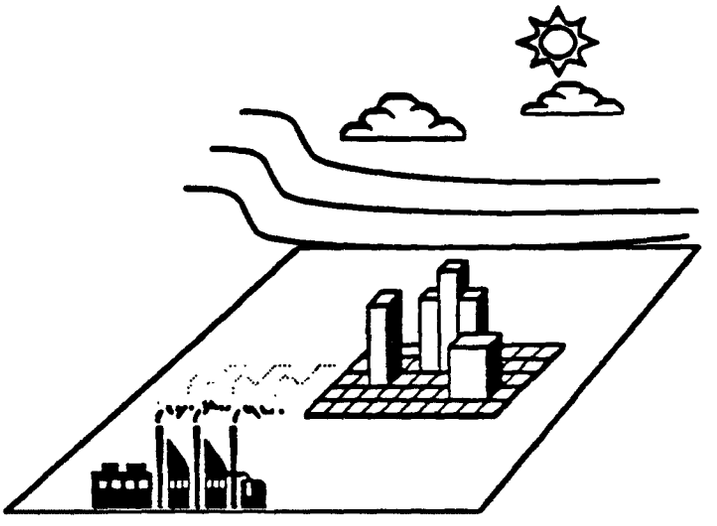
The first step in defining the grid system is selection of a grid boundary outlining the area to be modeled. Once the grid boundary has been chosen, the region enclosed by the grid boundary (subsequently referred to as the "modeling region" in this text) must be subdivided into grid cells. Figure 4-1 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.

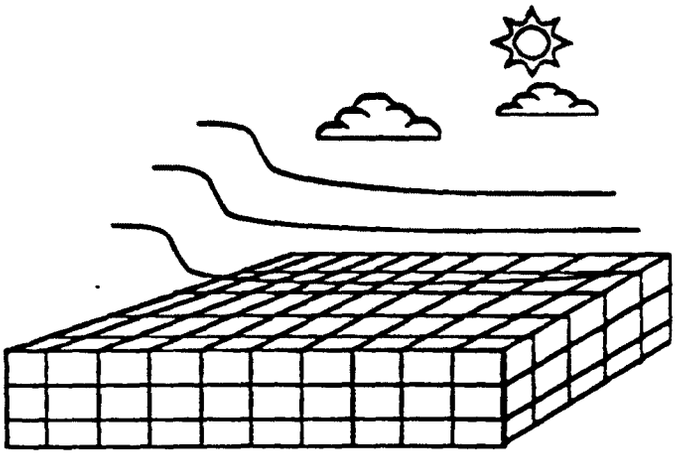
The modeling inventory must spatially resolve emissions in terms of the individual grid cells comprising the modeling region. A typical grid system will cover thousands of square kilometers and contain hundreds of grid cells.

- 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.

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



(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.

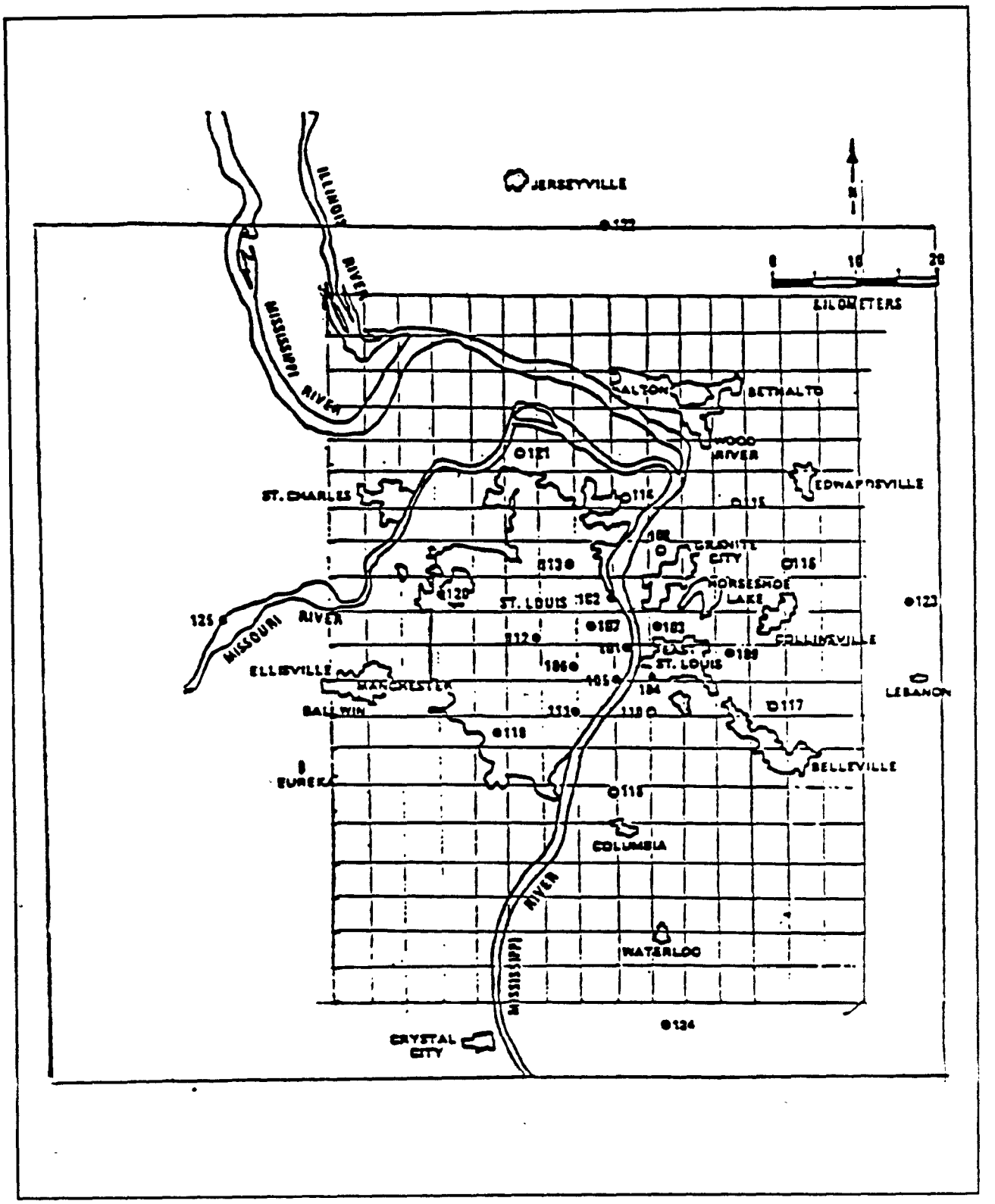


FIGURE 4-2. The St. Louis area with a 4 km by 4km modeling grid superimposed.

cells that compose the grid. Defining the grid system *before* beginning the modeling inventory development process will help minimize redundancy of effort.

In EPS 2.0, the modeling grid is defined in the /UAMREGN/ packet of the USERIN global user input file. The user must supply the following information in this packet:

- Reference origin (UTM Easting and Northing) and UTM zone
- Grid origin in X and Y directions (in meters, with respect to reference origin)
- Number and size of cells in X and Y directions
- Number of vertical cells in lower and upper layers
- Minimum vertical cell height for lower and upper layers

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 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. Thus, before a final grid system is chosen, a photochemical modeling specialist should be consulted regarding the effect of emission resolution on modeling predictions.

4.1.1 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 formats. For example, one area may 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 with AIRS.

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.

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.

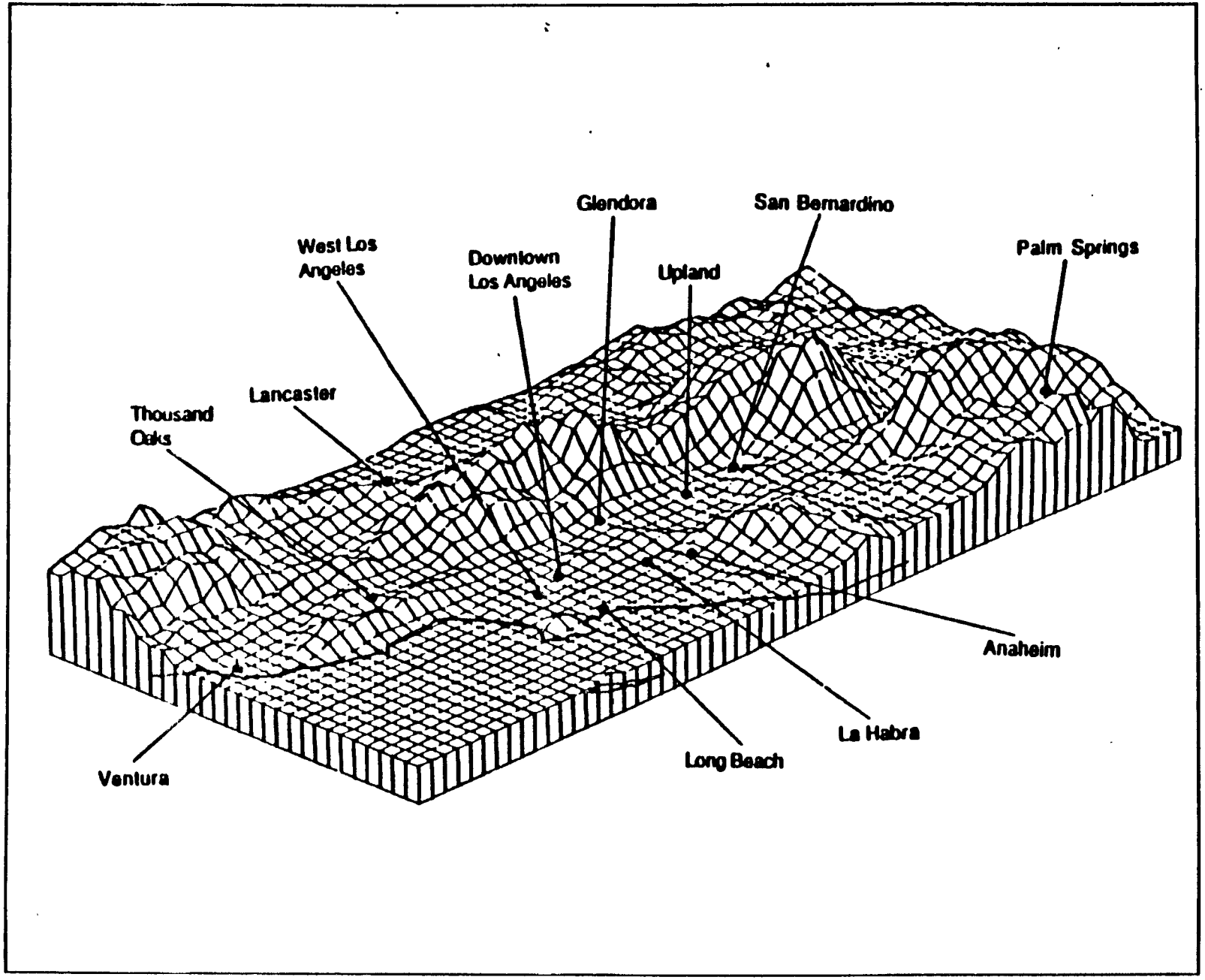


FIGURE 4-3. UAM modeling region for the California South Coast Air Basin.

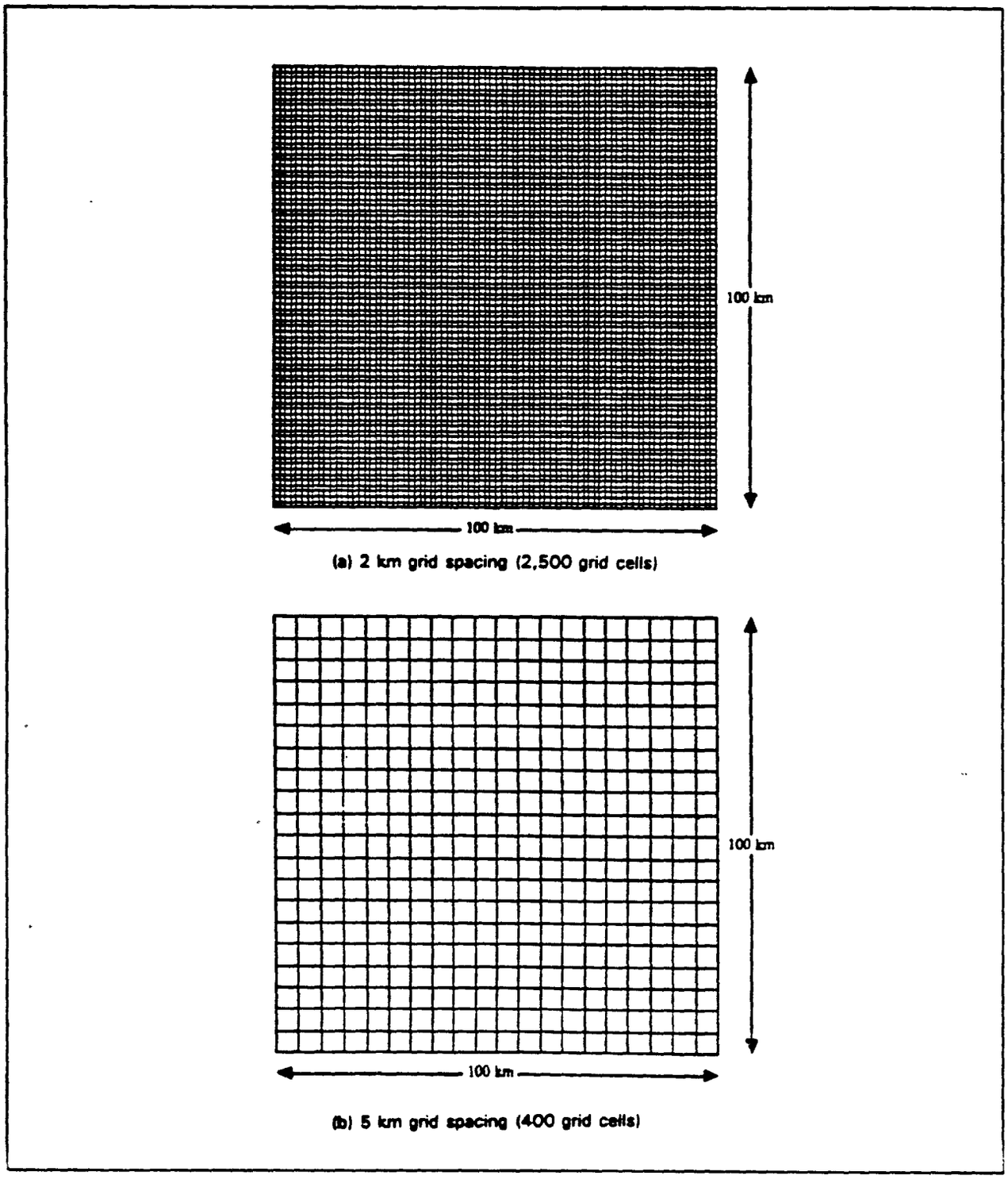


FIGURE 4-4. Comparison of number of grid cells required for a 100 km by 100 km modeling region for 2 km and 5 km grid spacings.

Resource considerations, however, 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.

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.

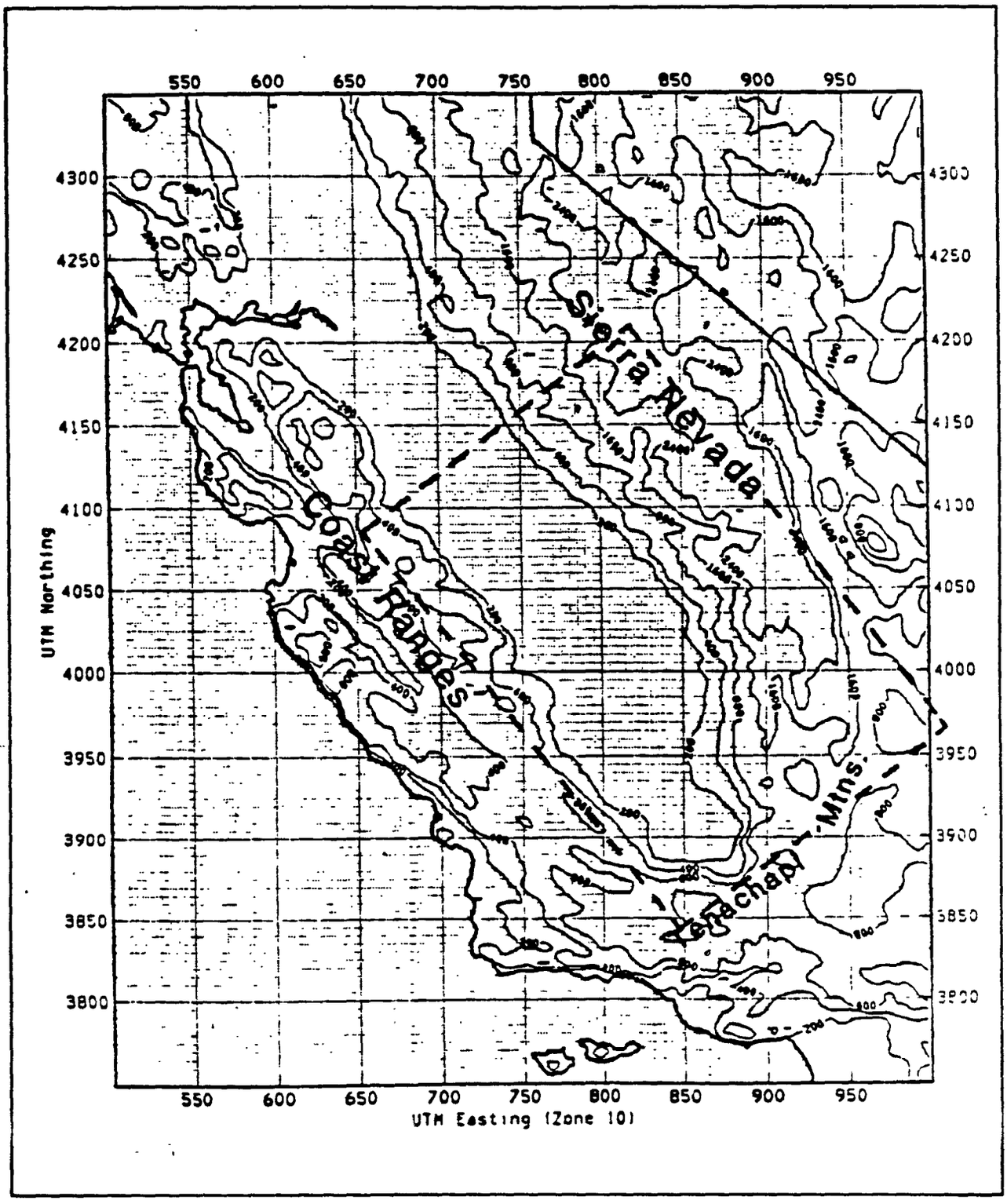


FIGURE 4-5. Rotated modeling region encompassing the southern San Joaquin Valley and Sierra Nevada.

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 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 or AIRS, 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 3-2 in Chapter 3 lists the data items included in the AIRS AFS work file format, which is the format required for input of point source emissions data into EPS 2.0.

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.

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.

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 1

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 (0.30)], 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 AIRS AFS work file-formatted point source emissions data file input to the EPS 2.0 module PREPNT, source location data may be reported in either UTM coordinates or as latitude and longitude in decimal degrees. A user input flag specifies which coordinate system has been used in the input emissions data file. If location data have been given as latitude and longitude, the PREPNT module will convert the locations to UTM coordinates, since these are the units used by the other EPS 2.0 modules. The GRDEM module assigns emissions from each point source to the appropriate grid cell, based on the UTM location for each source.

5.4 TEMPORAL RESOLUTION

The modeling inventory should represent as accurately as possible 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.

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.

Above-ground fixed-roof petroleum product storage tanks present a unique situation in that 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. Daily emissions from storage tanks can be estimated using procedures given in Volume I of EPA's *AP-42* document.[5]

The EPS 2.0 input file preparation utility, TMPFAC, will create and/or update the temporal profiles file and the source/temporal profiles cross reference file. These files are required inputs for the TMPRL module, which performs the actual temporal allocation. The TMPFAC utility also allows the user to create source-specific temporal allocation profiles based on the throughput and operating schedule information contained in the AIRS AFS (and AMS) workfiles. The monthly, weekly, and diurnal profiles defined in the default temporal profiles file provided with EPS 2.0 are shown in Appendix C.

TMPFAC examines the AIRS AFS workfile-formatted input emissions data files to retrieve the operating schedule data for each record. TMPFAC then compares this information with the profiles in the existing temporal profiles file. If none of the existing profiles match the operating schedule information contained in the input emissions file, TMPFAC will create new profiles and add a source-specific record to the source/temporal profile cross reference file to reflect the new assignments. TMPFAC assigns monthly profiles based on the data in the seasonal throughput fields. The seasonal throughput for a particular season is divided evenly among the months for that season, where the seasons are defined as follows:

Winter:	January, February, and March
Spring:	April, May, and June
Summer:	July, August, and September
Autumn:	October, November, and December

TMPFAC assigns weekly profiles for the AFS work file based on the data in the days/week in operation field; diurnal profiles are assigned based on the hours/day in operation. If an AFS record contains valid data in the (optional) "start hour" field, TMPFAC will use the start hour and the number of hours/day in operation to calculate the diurnal profile. Note that the diurnal profile calculated by TMPFAC will result in equal distribution of emissions over each hour the source is in operation. If actual hourly emissions data (perhaps reflecting hourly variations in activity levels) are available for some sources in the modeling region, the user may define new source-specific temporal profiles and incorporate the new profiles into the EPS 2.0 system input files using an ASCII text editior. The new profiles must be added to the appropriate packets (/MONTHLY/, /WEEKLY/, /DIURNAL WEEKDAY/, or /DIURNAL WEEKEND/) of the temporal profiles file, and the source/temporal profiles cross-reference file must be modified to reflect the new profile assignments.

TMPFAC assumes the following assignments regarding the operation schedule information retrieved from the AIRS work files:

Days per week	Hours per day
2 = Saturday and Sunday	8 = hours 0900 through 1600 (9 a.m. to 5 p.m.)
5 = Monday through Friday	12 = hours 0700 through 1800 (7 a.m. to 7 p.m.)
6 = Monday through Saturday	16 = hours 0800 through 2300 (8 a.m. to 12 a.m.)
7 = every day	24 = every hour

If a record specifies a number of days per week or hours per day other than those listed above (e.g., 1, 3, or 4 days per week or 6 hours per day), TMPFAC will assign temporal profiles by SCC code based on the default assignments listed in the source/temporal profiles cross reference file. If any of the operating schedule information is missing, TMPFAC will assume a flat operating profile for that source (i.e., 52 weeks/year, 7 days/week, and 24 hours/day, with no seasonal variation).

Although the formats of the default profiles and cross-reference files provided with EPS 2.0 allow these files to be input directly into the TMPRL core module, the user should use the TMPFAC utility to generate source-specific temporal distributions based on the information in the input emissions data file.

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 summarizes various methods for projecting point source emissions; consult the EPA document *Procedures for Preparing Emissions Projections*[6] for definitive guidance on the 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 for 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.

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 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).[7] 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 5-2 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 5-3 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 EPS 2.0, projection factors are applied by two-digit SIC designation. These projection factors are expressed as ratios of future year to base year activity levels indicators (e.g., number of employees); accordingly, a separate set of growth factors will be required for each projection year. The projection factors are included in the control factors input file used by the CNTLEM module.

The BEAFAC utility provided with EPS 2.0 will produce these factors for the user based on data contained in the Bureau of Economic Analysis' *Regional Projections to 2040* data base file, which is EPA's preferred data source for projecting future year activity for most stationary source categories. This file contains the following data for each state: population for three age groups, personal income (classified by major income component), and employment and earnings for 57 industrial groupings. For each of these categories, the BEA database contains historical data for 1973, 1979, 1983, and 1988, and projected data for 1995, 2000, 2005, 2010, 2020, and 2040.

For each state specified, BEAFAC calculates state-level projection factors for population and earnings by industry by dividing the projection year data by the base year data. If the specified year is one of the years provided in the BEA data files, these data will be used directly. If the year is not in the BEA data base, the data values required for calculating factors are determined by interpolating between the two closest years in the file. The base and projection years must be within the range of the BEA data base (i.e., between 1973 and 2040 inclusive). If the BEA data base does not contain enough data to calculate a projection factor, BEAFAC assigns a factor of 1.0.

The user can also specify a list of projection factors for individual SIC codes (or ASC code for area sources) that will override the data in the BEA data base. The SIC codes used for the user-supplied projection factors may be specified as either a 2-digit or 4-digit code, allowing projections for individual as well as grouped SIC classifications.

TABLE 5-2. 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**	11, 12
	Coal mining	13
	Oil and gas extraction	10
	Metal mining	14
	Nonmetallic minerals, except fuels	15, 16, 17
Construction	**Construction**	
Manufacturing	**Manufacturing**	
Nondurable goods	Nondurable goods	20
	Food and kindred products	21
	Tobacco manufacturers	22
	Textile mill products	23
	Apparel and other finished textile products	26
	Paper and allied products	27
	Printing and publishing	28
	Chemicals and allied products	29
	Petroleum and coal products	30
	Rubber and miscellaneous plastic products	31
	Leather and leather products	
Durable goods	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

continued

TABLE 5-2. Concluded.

Industries projected for MSAs	Industries projected for States and the Nation	1972 SIC code[1]
Transportation and public utilities	**Transportation and public utilities**	
	Transportation services	47
	Water transportation	44
	Communication	48
	Electric, gas and sanitary services	49
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 7

concluded

TABLE 5-3. 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	183.6	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	816.6	797.2
Railroad transportation	38.1	32.8	24.8	18.8	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 7

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 5-3, 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 Accounting for Regulatory Controls in Baseline Projections

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. 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.

EPA has published a series of Control Technique Guideline (CTG) documents that specify control requirements for a variety of sources and industries; these documents are summarized in Appendix C of *Volume I*.[3] The 1990 CAAA require that these controls be applied to all sources that meet the criteria specified in each document and which are located in moderate, serious, severe, and extreme ozone nonattainment areas. For sources affected by more than one title of the 1990 CAAA, the amendments mandate application of the more stringent control requirements. In particular, certain processes that emit toxic compounds are also subject to Maximum Available Control Technology (MACT) requirements. Under Section 112(d)(2) of Title III, the 1990 CAAA require facilities that emit 10 tons per year of any single air toxic or 25 tons per year of any combination of air toxics to meet standards based on MACT.

Non-CTG Reasonably Available Control Technology (RACT) controls apply only to individual processes not subject to CTG requirements. (Note that some CTGs specify the application of RACT in the control guidelines; for these sources, an appropriate cutoff should be determined based on the CTG requirements). Non-CTG RACT controls are applied to individual sources within a facility when the total of emissions from all non-CTG regulated processes for that facility exceeds the cutoff level for RACT applicability; the cutoff level is determined based on the ozone design value for the area.

The /COUNTY/ packet of the EPS 2.0 global USERIN file includes the ozone design value for each county in the modeling domain. CNTLEM uses this information to determine which of the regulatory controls specified in the control factors input file are applicable for a given source. For each CTG control to be applied, the user must specify the SCC codes for the processes subject to the regulation, a control factor for NO_x and VOC, and a cutoff limit for each pollutant which is used to determine CTG applicability. Although the individual CTG documents determine applicability based on a variety of parameters (throughput, capacity, etc.), CNTLEM requires the cutoff limit to be specified in terms of emissions rates. For MACT and RACT controls, the user need only specify control factors, since the cutoff limits for control applicability are determined based on the ozone design value for the county.

5.5.4 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.

In addition to the CTG, MACT, and RACT regulatory controls described above, the user may include additional controls to be applied for the sources in the modeling region in the CNTLEM control factors input file. These controls are referred to as "discretionary" controls to differentiate them from regulatory controls. The types of discretionary controls that may be specified in the control factors file are summarized briefly below.

Source- and Source Category-Specific Controls. The user may specify control parameters to be applied for individual sources or source categories using the /CONTROL EFFICIENCY/, /RULE EFFECTIVENESS/, and /RULE PENETRATION/ packets in the control factors files (rule penetration is a measure of the relative fraction of total sources for that source category which are subject to the regulation). Note that EPS 2.0 assumes that all new controls represent replacement technologies. Accordingly, if the input EMBR emissions data record contains data in the control efficiency (CE), rule effectiveness (RE), and rule penetration (RP) data fields, CNTLEM will use that data to calculate an uncontrolled emissions rate before applying the new controls, as shown in Equation 5-1:

$$E_S = E_0 \cdot \frac{1 - (CE_S \cdot RE_S \cdot RP_S)}{1 - (CE_0 \cdot RE_0 \cdot RP_0)} \qquad (5\text{-}1)$$

In this equation, E is the emission rate, the subscript 0 indicates the values from the input EMBR record, and the subscript S indicates the control scenario-specific values. If any of the factors (control efficiency, rule effectiveness, or rule penetration) are not present, CNTLEM assumes a default value for the missing factor of zero for control efficiency (representing no control) and one for rule effectiveness and rule penetration (representing 100 percent effectiveness and penetration).

Allowable Emissions Controls. CNTLEM will also adjust emissions based on user-specified allowable limits. These limits must be expressed as an emissions rate; accordingly, the user will

need to convert allowable emission limits expressed in terms of activity or emission factors. Allowable limits may be specified at the state, county, source category, facility, and individual source levels. A separate limit must be provided for each pollutant. Each control specified in the /ALLOWABLE/ packet of the control factors file is identified as either a replacement limit or an emissions cap. For replacement limits, the emissions in the input EMBR file are replaced with the allowable emission rates specified in the control factors file. For limits identified as caps, CNTLEM compares the emissions in the input EMBR file to the specified limit and substitutes the limit if the input emissions exceed the specified value.

Control Strategy Code Controls. The CNTLEM module allows the user to specify additional controls by control strategy code classification. CNTLEM supports five types of control strategy code classifications: activity, control, pod, process, and speciation profile. Appendix B lists the code definitions for each of the five types of control strategy codes. These code definitions correspond to the reporting category codes employed by the RPRTEM module.

Other Discretionary Controls. CNTLEM also supports the application of controls by state, county, and subregion code. In addition, the user may apply controls for a specified rectangular subgrid of the modeling region.

5.5.5 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:

- the choice of indicators for projecting activity level growth;
- when and where this growth will occur, and whether it will be accommodated by expansion of existing facilities or new construction; and
- 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.

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 photochemical models do not require that elevated point sources be assigned to grid cells (in the UAM, elevated point source locations are identified by UTM coordinates). In these models, preprocessor programs are available that make this assignment based on the point source coordinates available 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. One 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. Note, however, 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 5-4. 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 5-4. 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. 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.

2. *User's Guide for the Urban Airshed Model, Volume IV: User's Manual for the Emissions Preprocessor System 2.0, Part A: Core FORTRAN System*, EPA-450/4-90-007D (R), U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, May 1992.

3. *Procedures for the Preparation of Emission Inventories for Precursors of Ozone, Volume I: General Guidance for Stationary Sources*, EPA-450/4-91-016, U.S. Environmental Protection Agency (OAQPS), May 1991.

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 Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*, Fourth Edition and Supplements, AP-42, U.S. Environmental Protection Agency, September 1985.

6. *Procedures for Preparing Emissions Projections*, EPA-450/4-91-019, U.S. Environmental Protection Agency (OAQPS), July 1991.

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

6 AREA SOURCES

6.1 INTRODUCTION

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 offhighway mobile sources, such as construction and agricultural equipment, aircraft, locomotives, and marine vessels. As an example of a source classification scheme used to identify types of sources in the inventory, Table 6-1 lists the area source categories that must be addressed in emission inventories developed for State Implementation Plans.

- As a general rule, the maximum degree of source resolution should be maintained in the modeling inventory. For example, if separate emissions estimates have been prepared for dry cleaners using perchloroethylene and cleaners using petroleum-based solvents, this distinction should be maintained in the modeling inventory since it will permit more accurate speciation of the VOC emissions associated with 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 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.

TABLE 6-1. Area source categories required for consideration in State Implementation Plan emission inventories.

Stationary Source Fuel Combustion:

- Electric utility
- Industrial
- Commercial/Institutional
- Residential

Industrial Processes:

- Chemical manufacturing: SIC 28
- Food & kindred products: SIC 20
  - *Meat products*
  - *Grain mill products*
  - *Bakery products*
  - *Fermentation/beverages*
  - *Misc. food/kindred products*
- Primary metal: SIC 33
- Secondary metal: SIC 33
- Mineral processes: SIC 32
  - *Concrete, gypsum, plaster products*
  - *Cut stone & stone products*
- Petroleum refining: SIC 29
  - *Asphalt paving/roofing materials*
- Wood products: SIC 24
  - *Logging operations*
  - *Sawmills/planing mills*
  - *Millwork, plywood, & structural members*
  - *Miscellaneous wood products*
- Rubber/plastics: SIC 30
- Fabricated metals: SIC 34
  - *Coating, engraving, & allied services*
- Oil & gas production: SIC 13
  - *Crude petroleum*
  - *Natural gas*
  - *Natural gas liquids*
- Construction: SIC 15-17
  - *General building construction*
  - *Heavy construction*
  - *Road construction*
  - *Special trade construction*

Industrial Processes (continued):

- Machinery: SIC 35
  - *Metalworking machinery: tool & die makers*
- Mining & quarrying: SIC 14
  - *Dimension stone*
  - *Crushed & broken stone*
  - *Sand & gravel*
  - *Clay, ceramic, & refractory*
  - *Chemical & fertilizer materials*
- In-process fuel use
- All industrial processes

Solvent Utilization:

- Surface coating (all solvent types)
  - *Architectural coatings*
  - *Auto refinishing*
  - *Textile products*
  - *Flatwood products*
  - *Wood furniture*
  - *Metal furniture*
  - *Paper*
  - *Plastic products*
  - *Cans*
  - *Metal coils*
  - *Misc. finished metals*
  - *Electrical*
  - *Large appliances*
  - *Magnet wire*
  - *Motor vehicles*
  - *Aircraft*
  - *Marine*
  - *Railroad*
  - *Miscellaneous manufacturing*
- Degreasing (all solvent types)
  - *Open top degreasing*
  - *Conveyorized degreasing*
  - *Cold cleaning degreasing*

continued

TABLE 6-1. Continued.

Solvent Utilization (continued):

- Dry cleaning
  - *Perchloroethylene*
  - *Petroleum*
- Graphic arts (all solvent types)
  - *Lithography*
  - *Letterpress*
  - *Rotogravure*
  - *Flexography*
- Rubber/plastics
- Miscellaneous industrial
- Miscellaneous non-industrial
  - *Film roofing: all solvent types*
- Adhesive application
- Commercial/consumer
- Pesticide application
- Asphalt application (all solvent types)
  - *Cutback asphalt*
  - *Emulsified asphalt*
  - *Asphalt roofing*
  - *Asphalt pipe coating*
- Solvent reclamation
- Tank/drum cleaning
- All solvent use categories: all solvent types

Storage & Transport:

- Gasoline marketing (service stations & outlets)
  - *Stage I (underground tank filling):*
    - *Splash fill*
    - *Submerged fill*
    - *Balanced submerged fill*
  - *Stage II (vehicle refueling):*
    - *Displacement losses*
    - *Spillage*
  - *Underground tank breathing & emptying*
- Petroleum & petroleum product storage
  - *Commercial/industrial (all products)*
  - *Bulk stations/terminals (all products)*

Storage & Transport (continued):

- Petroleum & petroleum product transport
  - *Rail tank car (all products)*
  - *Marine vessel (all products)*
  - *Truck (all products)*
  - *Pipeline (all products)*
- Organic chemical storage (all products)
  - *Commercial/industrial*
  - *Bulk stations/terminals*
- Organic chemical transport (all products)
  - *Rail tank car*
  - *Marine vessel*
  - *Truck*
  - *Pipeline*
- Inorganic chemical storage (all products)
  - *Commercial/industrial*
  - *Bulk stations/terminals*
- Inorganic chemical transport (all products)
  - *Rail tank car*
  - *Marine vessel*
  - *Truck*
  - *Pipeline*
- Bulk materials storage (all products)
  - *Commercial/industrial*
  - *Bulk stations/terminals*
- Bulk materials transport (all products)
  - *Rail tank car*
  - *Marine vessel*
  - *Truck*

Waste Disposal, Treatment, & Recovery:

- On-site incineration
  - *Industrial*
  - *Commercial/institutional*
  - *Residential*
- Open burning
  - *Industrial*
  - *Commercial/institutional*
  - *Residential*

continued

TABLE 6-1. Concluded.

Waste Disposal, Treatment, & Recovery (continued):

- Landfills
  - *Industrial*
  - *Commercial/institutional*
  - *Municipal*
- Wastewater treatment
  - *Industrial treatment works (TWs)*
  - *Publicly owned TWs*
  - *Residential/subdivision owned TWs*
- Hazardous waste treatment, storage, & disposal facilities (TSDFs)
  - *Industrial TSDFs*
  - *Commercial/institutional TSDFs*
- Scrap & waste materials

Natural Sources:

- Biogenic
  - *Forests*
  - *Vegetation*
  - *Soil*
- Geogenic
  - *Volcanos*
  - *Geysers/geothermal*
  - *Wind erosion*
- Miscellaneous natural sources
  - *Lightning*
  - *Fresh water*
  - *Salt water*

Miscellaneous Area Sources:

- Agricultural production - crops
  - *Agricultural field burning*
  - *Orchard heaters*
  - *Country grain elevators*
- Agricultural production - livestock
  - *Beef cattle feedlots*
  - *Poultry operations*
  - *Dairy operations*
  - *Hog operation*
- Other combustion
  - *Forest wildfires*
  - *Managed (slash/prescribed) burning*
  - *Charcoal grilling*
  - *Structural fires*
  - *Firefighting training*
  - *Aircraft/rocket engine firing & testing*
- Cooling towers
  - *Cooling towers*
  - *Process cooling towers*
  - *Comfort cooling towers*
- Catastrophic/accidental releases
  - *Industrial accidents*
  - *Transportation accidents*
- Automotive repair shops
  - *Auto top & body repair shops*
  - *Automotive exhuast repair shops*
  - *Tire retreading & repair shops*
- Miscellaneous repair shops
  - *Welding repair shops*
- Health services
  - *Hospitals*

source: Reference 7 *concluded*

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 system input and glossary files provided with EPS 2.0 use the AIRS AMS source category codes for area and mobile sources; this coding system classifies each source type using a ten-digit numerical code. The AIRS AMS classification system is hierarchial, with four levels of detail (specified by digits 1-2, digits 3-4, digits 5-7, and digits 8-10, respectively) as shown in the example below:

AIRS AMS Code	Description
24 xx xxx xxx	Solvent utilization
24 01 xxx xxx	Surface coating operations
24 01 001 xxx	Architectural coatings
24 01 001 030	Architectural coatings: Acetone

To obtain a complete list of the AIRS AMS source category codes currently supported by the AIRS system, consult the GEOCOMMON file which may be accessed using the online AIRS system.

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 these 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* of the 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 subcounty 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. Use engineering judgment to select appropriate indicators for apportioning area source emission totals, and consult local authorities to verify the applicability of the source category/spatial surrogate indicator pairings for a 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 6-2 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 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 6-3 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.

Often, the most representative way to spatially distribute emissions from some off-highway mobile sources that are commonly included in the area source inventory, such as railroad locomotives,

TABLE 6-2. Example spatial allocation surrogates for selected area source categories.	
Emissions Category	**Surrogate Indicator**
Residential Fuel Combustion	Housing
Commercial/Institutional Fuel Combustion	Urban Landuse
Industrial Fuel Combustion	Urban Landuse
Onroad Vehicles - Limited Access Roadways	Link Location
Onroad Vehicles - Rural Roadways	Rural Landuse
Onroad Vehicles - Urban Roadways	Urban Landuse
Off-Highway Vehicles	County Area
Railroad Locomotives	Link Location
Aircraft - Commercial	Airport Location
Vessels	Water
Gasoline Marketed	Population
Unpaved Roads	County Area
Unpaved Airstrips	County Area
Forest Wild Fires	Composite Forest
Managed Burning - Prescribed	Composite Forest
Agricultural Operations	Agricultural Landuse
Structural Fires	Housing
Degreasing	Population
Drycleaning	Population
Graphic Arts/Printing	Population
Rubber and Plastic Manufacturing	Population
Architectural Coating	Population
Auto Body Repair	Population
Motor Vehicle Manufacturing	Population
Paper Coating	Population
Fabricated Metals	Population
Machinery Manufacturing	Population
Furniture Manufacturing	Population
Flat Wood Products	Population
Other Transportation Equipment Manufacturing	Population
Electrical Equipment Manufacturing	Population
Ship Building and Repair	Water
Miscellaneous Industrial Manufacturing	Population
Miscellaneous Solvent Use	Population
Publicly Owned Treatment Works (POTWs)	Population
Cutback Asphalt Paving Operation	Population
Fugitives from Synthetic Organic Chemical Mfg.	County Area
Bulk Terminal and Bulk Plants	Population
Fugitives from Petroleum Refinery Operations	Population
Process Emissions from Bakeries	Population
Process Emissions from Pharmaceutical Mfg.	Population
Process Emissions from Synthetic Fibers Mfg.	Population
Crude Oil and Natural Gas Production Fields	Population
Hazardous Waste Treatment, Storage and Disposal Facilities	Population

TABLE 6-3. 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.

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 EPS 2.0 module 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. Refer to Section 7.6, regarding spatial distribution of onroad mobile source emissions, for additional information on the specification of link data for use with EPS 2.0.

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 6-4. 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 6-4), 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 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

TABLE 6-4. 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
23 Confined feeding operation	73 Sandy areas, other
24 Other agricultural land	75 Strip mines, quarries, and gravel pits
	76 Transitional areas
	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

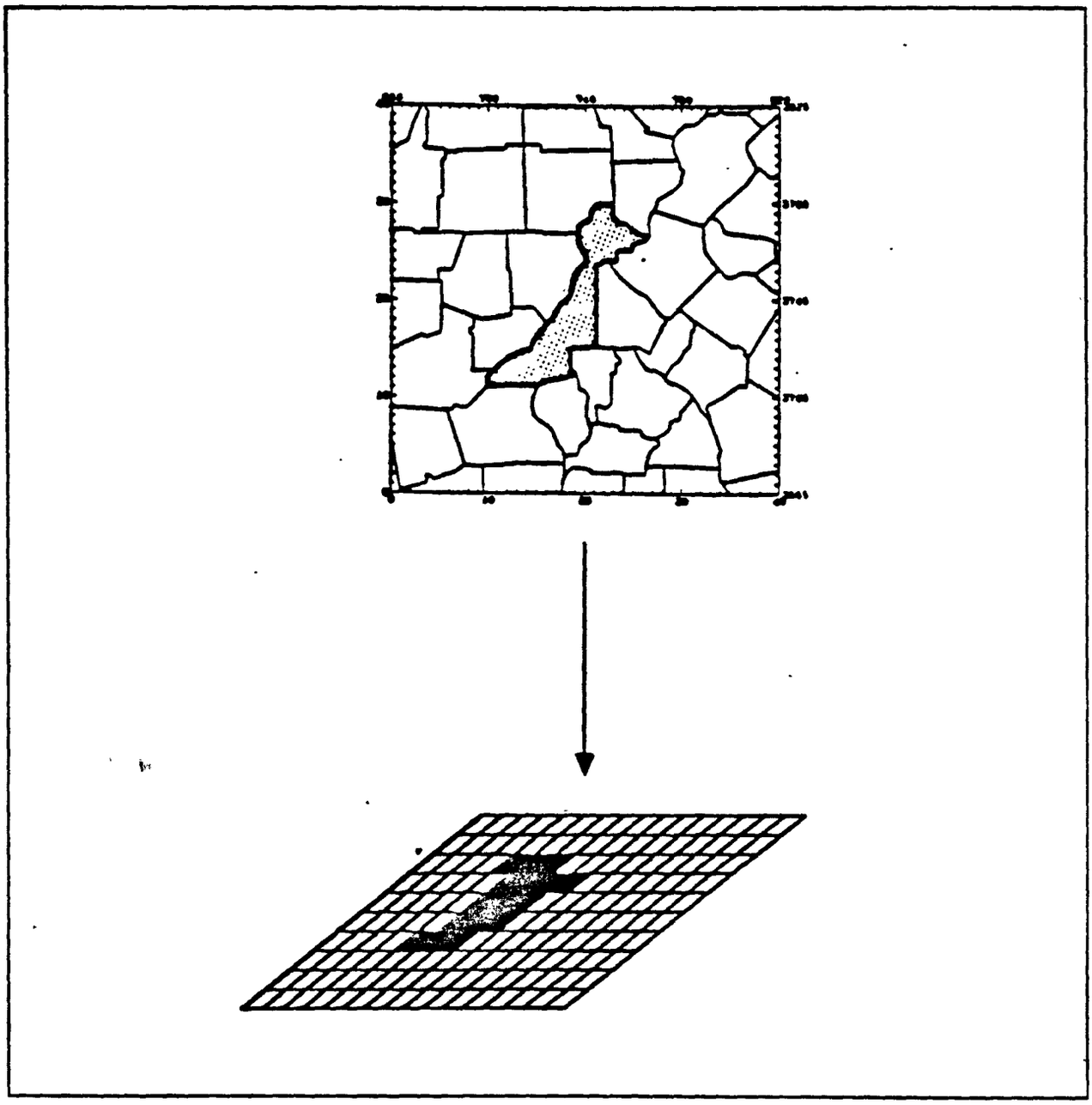


FIGURE 6-1. Conceptual representation of the grid cell identification process.

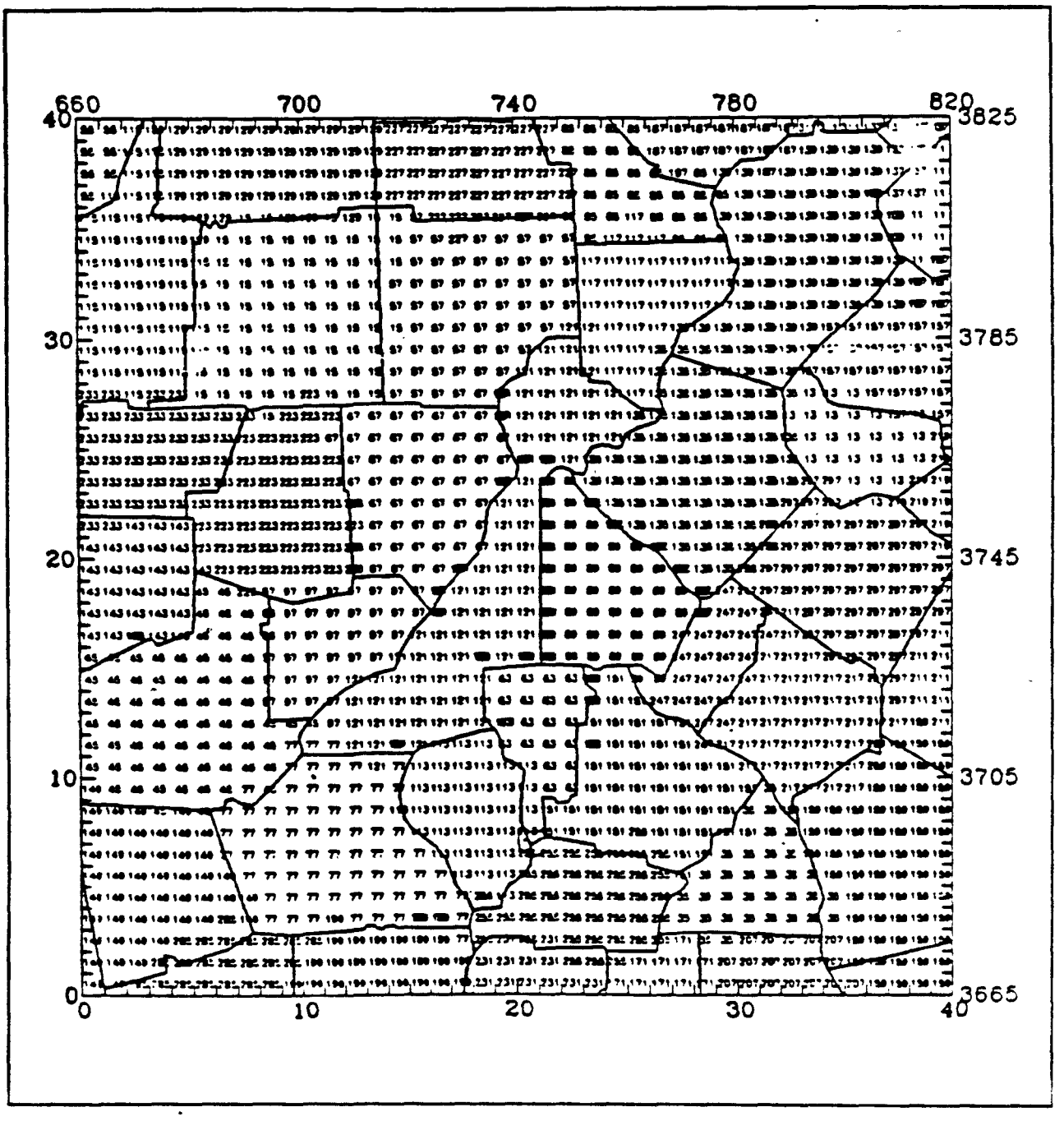


FIGURE 6-2. County grid cell assignments for the Atlanta, Georgia modeling region.

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 6-5 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.

  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.

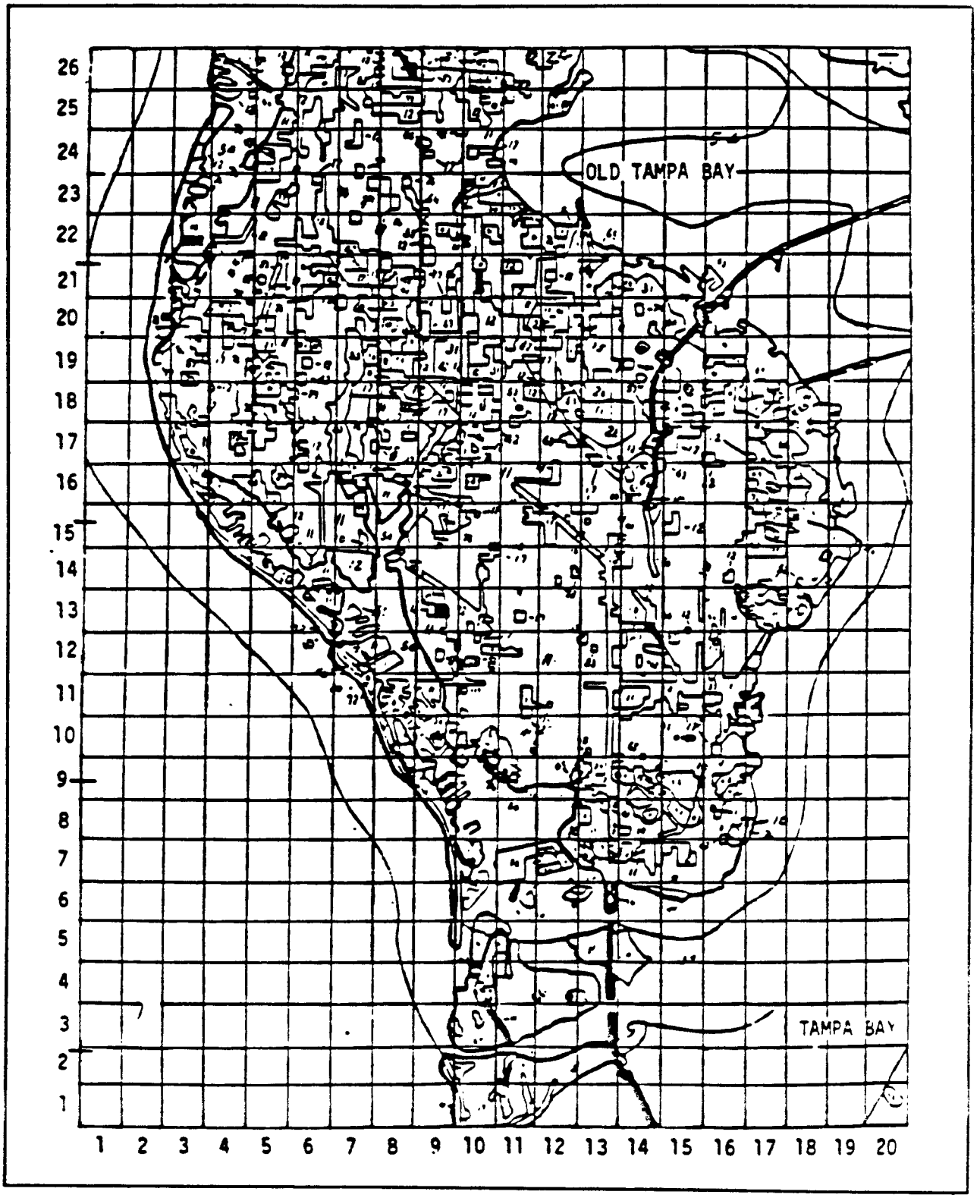


FIGURE 6-3. Segment of land use map for Tampa Bay, Florida.

TABLE 6-5. Land use categories for Tampa Bay area land use map (Figure 6-3).

1. URBAN OR BUILT-UP LAND
- 10 Multi-family residential
- 11 Single family residential
- 12 Commercial and service
- 13 Industrial
- 14 Transportation, communication and utilities
- 15 Industrial and commercial combined
- 16 Mixed urban or built-up land
- 17 Other urban or built-up land

2. AGRICULTURAL LAND
- 23 Confined feeding operation
- 24 Other agricultural land
- 25 Cropland
- 26 Improved pasture
- 27 Specialty farms
- 28 Orchards, groves, vineyards, nurseries, and ornamental horticultural groves
- 29 Citrus groves

3. RANGELAND
- 31 Herbaceous rangeland
- 32 Shrub and brush rangeland
- 33 Mixed rangeland

4. FOREST LAND
- 41 Deciduous forest land
- 42 Evergreen forest land
- 43 Mixed forest land

5. WATER
- 51 Streams and canals
- 52 Lakes
- 53 Reservoirs
- 54 Bays and estuaries

6. WETLAND
- 63 Freshwater forested wetland
- 64 Freshwater marsh
- 65 Saltwater forested wetland
- 66 Saltwater marsh

7. BARREN LAND
- 72 Beaches
- 73 Sandy areas other than beaches
- 75 Extractive
- 76 Transitional areas

source: Reference 5

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.

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 6-5).

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

$$f_{ik} = \left(\sum_{j=1}^{3} W_{jk} S_{ij}\right) / \left[\sum_{i=1}^{n} \left(\sum_{j=1}^{3} W_{jk} S_{ij}\right)\right] \qquad (6\text{-}3)$$

  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 6-6, 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 6-6 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 6-6, 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 6-7 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 6-7.

  Assume that area source degreasing emissions in a given county are 42 tons/day of VOC. According to Table 6-7, 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:

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

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

Variable[a] Name	SIC[b] Classification	Description
DWELL	(not applicable)	Dwelling units
AGRI	1, 7-9	Agriculture, forestry
MIN	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 6-7. 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
CHEMICAL										
Misc. Chem. Proc										
OTHER IND./COM.										
Metallurgical					90			10		
Mineral - Concrete					100					
Mineral - Stone/Sand/Gravel	10		40		50					
Mineral - Sand Blast					10			5		10
Misc. Mineral Proc.			10		90					
Farming Operations		100								
Food/Agricultural Proc.						100				
Paint Spray Mist	5				10			70		
Wood Products Mfg.	10								80	
Misc. Inc./Com. Proc.							30	30	30	
GASOLINE DISTRIBUTION										
Vehicle Fill Station -										
- Spillage										5
- Storage Tanks										5
- Vehicle Tanks										5
OTHER ORG. COMP. EVAP.										
Storage Tanks -										
- Solvent					20		20	20	20	10
- Misc. Org. Comp.		5	10		20	15	10	10	10	10
Ind. Coat. - Solv. Base				10	10		10	50	10	
Ind. Coat. - Water Base								90	5	
Com. & Dom. Coat.										
- Solv. Base	64	3	3							3
- Water Base	64	3	3							3
Degreasers							10	60		
Drycleaners - PERC										
Drycleaners - Misc. solvents										
Rubber Fabrication					100					
Plastic Fabrication					90					
Printing				100						
Misc. Org. Evap.	10	5	5		50		5	5	5	

continued

TABLE 6-7. Concluded.

Source Classification	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									
Mineral - Concrete									
Mineral - Stone/Sand/Gravel									
Mineral - Sand Blast	5	5	5	10	10	10	10	10	10
Misc. Mineral Proc.									
Farming Operations									
Food/Agricultural Proc.									
Paint Spray Mist								15	
Wood Products Mfg.								10	
Misc. Inc./Com. Proc.								10	
GASOLINE DISTRIBUTION									
Vehicle Fill Station -									
- Spillage						90			5
- Storage Tanks						90			5
- Vehicle Tanks						90			5
OTHER ORG. COMP. EVAP.									
Storage Tanks -									
- Solvent	5							5	
- Misc. Org. Comp.	5								5
Ind. Coat. - Solv. Base								10	
Ind. Coat. - Water Base								5	
Com. & Dom. Coat.									
- Solv. Base	3	3	3	3	3	3	3	3	3
- Water Base	3	3	3	3	3	3	3	3	3
Degreasers								20	10
Drycleaners - PERC								100	
Drycleaners - Misc. solvents								100	
Rubber Fabrication									
Plastic Fabrication								10	
Printing									
Misc. Org. Evap.								10	5

source: Reference 6 *concluded*

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 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 6-6) 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 6-8 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.

  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:

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

TABLE 6-8. Illustrative excerpts from zone-to-grid-cell correspondence table for determining apportioning factors.

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

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)

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 fractional area of zone j in cell i. Note that the value of g_{ij} is given by

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

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.,

$$f_{i,k} = a_{ik} \; / \; \Sigma_i \, a_{ik} \tag{6-6}$$

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

$$\Sigma_i \, a_{ik} = \Sigma_j \, b_{jk} \tag{6-7}$$

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. 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

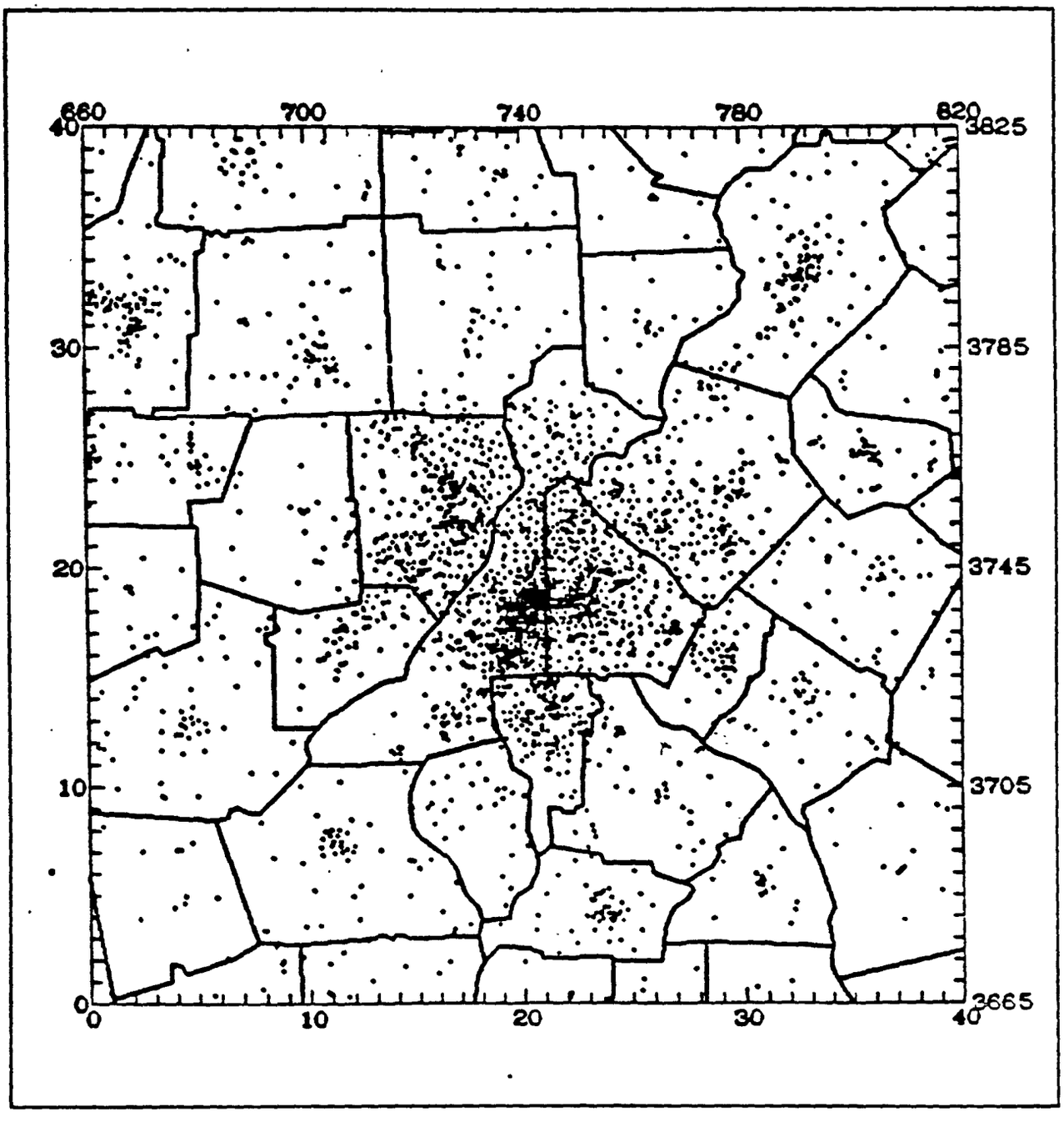


FIGURE 6-4. Location of block group enumeration centroids for the Atlanta, Georgia modeling region.

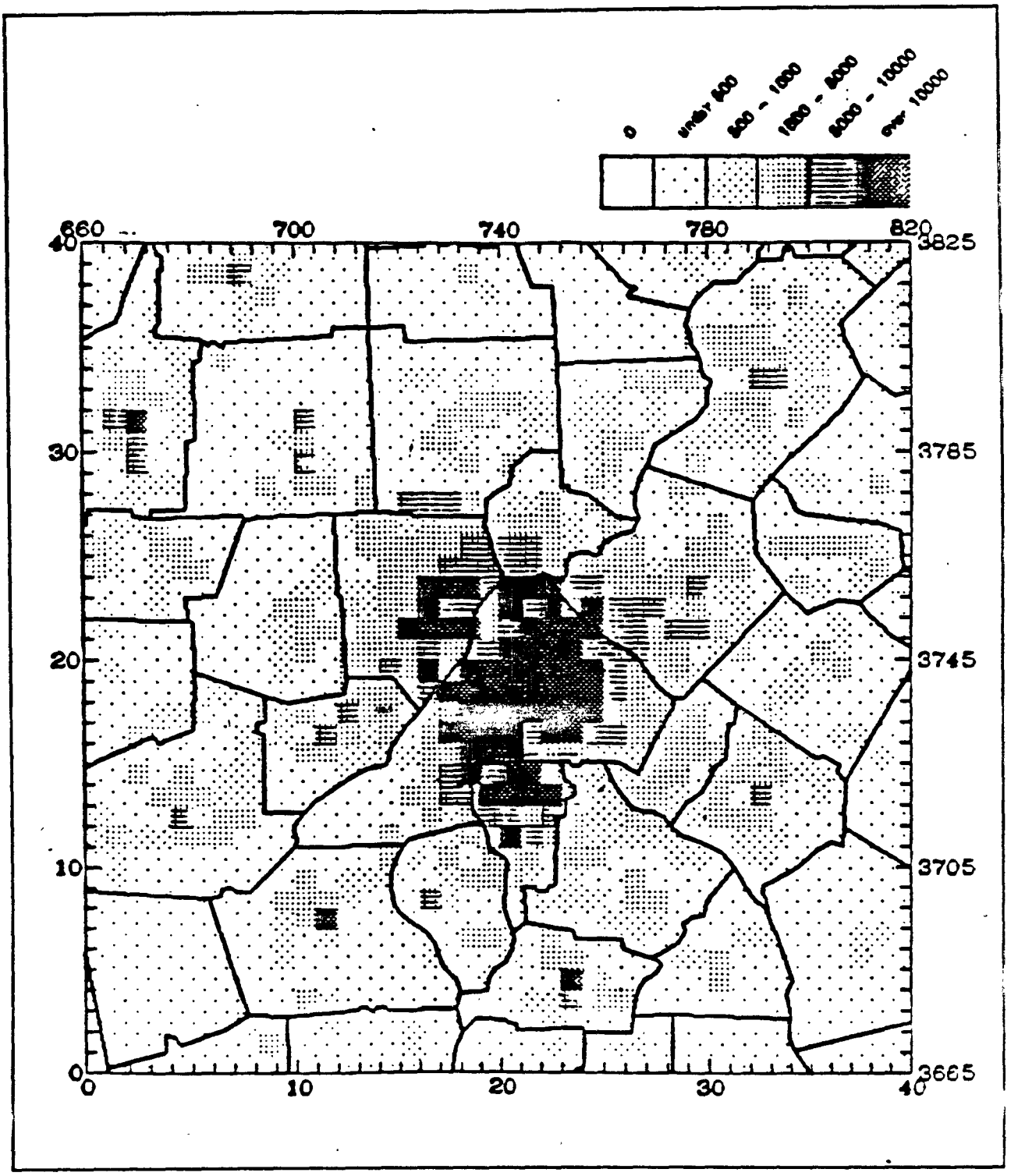


FIGURE 6-5. Sample gridded population data for the Atlanta, Georgia modeling region.

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 sometimes 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 6-9 lists recommended seasonal adjustment factors for selected 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 EPS 2.0 core module TMPRL temporally allocates area (and mobile) source emissions based on the temporal profiles assigned for each area source category (ASC) in the source/temporal profiles cross reference file. The temporal profiles are defined in a separate file, which may contain up to four packets of profile definitions: /MONTHLY/, /WEEKLY/, /DIURNAL WEEKDAY/, and /DIURNAL WEEKEND/. Appendix C shows the profiles which are currently included in the default temporal profiles definition file provided with EPS 2.0.

Temporal profiles in the /MONTHLY/ packet are defined by assigning a relative weight factor for each month which indicates the monthly contribution to total annual activity. The TMPRL module divides the weight factor for each month by the sum of all 12 weight factors to determine the fraction of annual activity occurring in each month. The seasonal adjustment factors in Table 6-9 can be converted to monthly weight factors for use in this file as described below.

TABLE 6-9. 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

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 6-9 for architectural surface coating is 1.3; accordingly, the monthly fraction will be (1.3) / (12), or 0.108. For the other nine 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.

In the temporal profiles definition file, the weight factors for each month must be expressed as integer values. Accordingly, the values calculated above may be multiplied by 1000 to construct the weight factors to be entered into this file, as shown below:

Season	Weight factor for each month in season			Total weight for season
Winter	75	75	75	225
Spring	75	75	75	225
Summer	108	108	108	324
Fall	75	75	75	225
				999

If the inventory already contains peak season or episodic emission estimates (i.e., if the inventory type designation in the input emissions data file is "PO", "PC", or "S", indicating peak ozone typical day, peak CO typical day, or specified interval, respectively), TMPRL will not apply a seasonal adjustment.

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 6-10 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.

In EPS 2.0, this type of hourly operating information can be incorporated into the modeling inventory by defining new temporal profiles for the appropriate area source categories. An ASCII text editor can be used to add the new profiles to the temporal profiles definition file and modify the corresponding assignments in the source/temporal profiles cross reference file accordingly.

The hourly operating information in Table 6-10 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 6-11 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 6-11. 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 to project future year levels 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. The emissions modeler should consult current EPA guidance on projection of future year emission inventories when identifying appropriate growth indicators for the various source categories.

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.

TABLE 6-10. 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 6-11. 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-Saturday	uniform 0600 to 2000, otherwise zero
Drycleaning	uniform	uniform Monday-Saturday	uniform 0700 to 1900, otherwise zero
Degreasing	uniform	uniform Monday-Saturday	80% 0700 to 1900; 20% 1900 to 2400
Nonindustrial surface coating	uniform	uniform Monday-Saturday	uniform 0700 to 1900, otherwise zero
Cutback asphalt	uniform spring through fall	Monday-Friday	uniform 0700 to 1900, otherwise zero
Pesticide application	coincides with growing season	uniform	daylight hours (0700 to 1900)
Miscellaneous solvent use	uniform	uniform	80% from 0700 to 1900 20% from 2000 to 2400
Aircraft, general	uniform	60% Mon-Fri; 40% Sat-Sun	uniform 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 0700 to 2100, otherwise zero
Construction equipment	20% December-February 25% March-May 30% June-August 25% September-November	Monday-Saturday	uniform 0700 to 1900 Monday-Friday uniform 0700 to 1200 Saturday
Industrial equipment	20% December-February 25% March-May 30% June-August 25% September-November	uniform Monday-Saturday	80% from 0700 to 1900 20% from 1900 to 2400
Lawn and garden equipment	uniform through months which have an average temperature of 38°F or higher	50% Mon-Fri 50% Sat-Sun	uniform 0900 to 1900, otherwise zero
Off-highway motorcycles	base on monthly off-highway fuel use	30% Mon-Fri; 70% Sat-Sun	
Snowmobiles	base on monthly off-highway fuel use	30% Mon-Fri; 70% Sat-Sun	

continued

TABLE 6-11. Concluded.

Source Category	Seasonal	Daily	Hourly
Small pleasure craft	uniform through months which have an average temperature of 45°F or greater	30% Mon-Fri 70% Sat-Sun	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 1900 25% from 1900 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% Mon-Sat 5% Sunday	90% from 0600 to 2400 10% from 2400 to 0600
Industrial fuel combustion	uniform	uniform Mon-Sat	80% from 0700 to 1800 20% from 1800 to 2400 otherwise zero
Solid waste disposal, on-site incineration, open burning	uniform	91% Mon-Fri 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 0500 to 2100
Fires: forest wildfires, structural fires	uniform	uniform	uniform
Waste management practices (POTWs, TSDFs)	uniform	uniform	uniform

source: References 1, 2

concluded

- 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 $[1.05]^5$, or 1.28 (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.

In EPS 2.0, area source emissions are projected based on either the first four digits of the area source category (ASC) code or the entire ten-digit code. The projection factors for each ASC, which are applied using the CNTLEM module, are included in the control factors input file. The BEAFAC utility, described in Section 5.5.2, will calculate projection factors for four-digit ASCs using the BEA projections of population and industrial earnings.

Table 6-12 lists growth indicators and potential information sources for selected area source categories, as suggested in the EPA guidance document *Procedures for Preparing Emissions Projections*.[8] 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 the base year is multiplied by the area source activity level in the base year to yield the projection year activity level.

TABLE 6-12. Preferred growth indicators for projecting emissions for area source categories.

Source Category	Growth Indicators	Information Sources
Gasoline marketing	projected gasoline consumption	MOBILE fuel consumption model
Dry cleaning	population; retail service employment	solvent suppliers; trade associations
Degreasing (cold cleaning)	industrial employment	trade associations
Architectural surface coating	population or residential dwelling units	local MPO
Automobile refinishing	industrial employment	BEA
Small industrial surface coating	industrial employment	BEA
Graphic arts	population	state planning agencies; local MPO
Asphalt use - paving	consult industry	consult industry
Asphalt use - roofing	industrial employment; construction employment	local industry representatives
Pesticide application	historical trends in agricultural operations	state department of agriculture; local MPO
Commercial/consumer solvent use	population	local MPO; state planning agencies
Publicly Owned Treatment Works (POTWs)	site-specific information	state planning agencies
Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDFs)	state planning forecasts	state planning agencies; local MPO
Municipal solid waste landfills	state waste disposal plan	local MPO; state planning agencies
Commercial/institutional fuel combustion	residential housing units or population	local MPO
Industrial fuel combustion	commercial/institutional employment; population	local MPO; land use projections; state planning agencies

continued

TABLE 6-12. Concluded.

Source Category	Growth Indicators	Information Sources
Aircraft (commercial and general)	site-specific forecasts	local airport authorities and commercial carriers
Aircraft (military)	site-specific forecasts	local airport authorities; appropriate military agencies
Railroads	revenue ton-miles	American Association of Railroads and local carriers
Ocean-going and river cargo vessels	cargo tonnage	local port authorities; US Maritime Administration; US Army Corps of Engineers
Vessels, small pleasure craft	population	local MPO
Off-highway motorcycles	population	local MPO
Agricultural equipment	agricultural land use; agricultural employment	local MPO; Census of Agriculture
Construction equipment	industry growth (SIC code 16)	local MPO
Industrial equipment	Industrial employment (SIC codes 10-14, 20-39, 50-51) or industrial land use area	local MPO
Lawn and garden equipment	single-unit housing	local MPO
On-site incineration	based on information gathered from local regulatory agencies	local regulating agencies and MPO; state planning agencies
Open burning	based on information gathered from local regulatory agencies	local agencies; state planning agencies; local MPO
Fires: managed burning, agricultural field burning, frost control (orchard heaters)	areas where these activities occur	US Forest Service; state agriculture extension office
Forest wildfires	historical average	local, state, and federal forest management officials
Structural fires	population	local MPO; state planning agencies

source: Reference 8

concluded

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 6-13 shows a sample excerpt from such a file. This file basically consists of a matrix of apportioning factor values by grid cell. In Table 6-13, 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.

The EPS 2.0 module GRDEMS performs the calculations described above. This module uses a cross reference input file of area source categories and spatial surrogate indicators, which specifies which indicators will be used to allocate emissions from which source categories. The default cross-reference file provided with EPS 2.0 may be modified to include county- or source category-specific spatial surrogate assignments, or to redefine the spatial surrogate indicator codes. As an example, the user might redefine the surrogate code designations for a rarely used land use surrogate (such as barren, or rocky with lichens) to incorporate special spatial apportioning information for one or more counties, such as detailed location data for gasoline service stations. Consult the *User's Guide for the Urban Airshed Model, Volume IV: User's Guide for the Emissions Preprocessor System*[3] for additional guidance and specific format requirements for the spatial apportioning file.

TABLE 6-13. 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 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.

References for Chapter 6:

1. *Procedures for the Preparation of Emission Inventories for Precursors of Ozone, Volume I: General Guidance for Stationary Sources*, EPA-450/4-91-016, U.S. Environmental Protection Agency (OAQPS), May 1991.

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 Manual for the Emissions Preprocessor System 2.0, Part A: Core FORTRAN System*, EPA-450/4-90-007D (R), U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, May 1992.

4. *Procedures for Estimating and 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. *Emission Inventory Requirements for Ozone State Implementation Plans*, EPA-450/4-91-010, U.S. Environmental Protection Agency (OAQPS), March 1991.

8. *Procedures for Preparing Emissions Projections*, EPA-450/4-91-019, U.S. Environmental Protection Agency (OAQPS), July 1991.

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. For inventory purposes, mobile sources are typically categorized as

- Onroad vehicles;
- Offroad vehicles;
- Aircraft;
- Railroad locomotives; and
- Vessels.

Onroad 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. Offroad vehicles include all recreational vehicles and machinery used in off-road situations, such as farm equipment, construction equipment, snow mobiles, off-road motorcycles, etc. Together, offroad sources and aircraft, railroad locomotives, and vessels (which represent all vehicles used in air, rail, and water transportation, respectively) are sometimes referred to as "other mobile" sources; these sources, however, should be maintained as separate source categories in the modeling inventory to facilitate spatial, temporal, and chemical resolution of emissions. To provide an example of a source classification scheme for mobile sources, Tables 7-1, 7-2, and 7-3 list the source category codes employed by the AIRS Area and Mobile Subsystem for onroad, offroad, and other mobile sources.

As mentioned in Chapter 6, an existing annual or seasonal area source emission inventory generally contains adequate estimates of emissions for all sources except onroad motor vehicles. Since the Urban Airshed Model will be applied for a particular episode, the mobile source emissions must be either calculated 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 onroad vehicles (for offroad mobile sources, the methods described in Chapter 6 may be employed).

TABLE 7-1. AIRS AMS codes for onroad mobile sources (each code is ten characters long; characters 1 and 2 are always "22", indicating Mobile Sources).

Characters 3 and 4: Fuel Type	Characters 5, 6, and 7: Vehicle Type
01 Highway Vehicles - Gasoline	001 Light Duty Gas Vehicles (LDGV) 020 Light Duty Gas Trucks 1 (LDGT1) 040 Light Duty Gas Trucks 2 (LDGT2) 060 Light Duty Gas Trucks 1 & 2 (LDGT) 070 Heavy Duty Gas Vehicles (HDGV) 080 Motorcycles (MC)
30 Highway Vehicles - Diesel	001 Light Duty Diesel Vehicles (LDDV) 060 Light Duty Diesel Trucks (LDDT) 070 Heavy Duty Diesel Trucks (HDDT)

Characters 8, 9, and 10: Roadway Classification	
000 Total: All Road Types	230 Interstate: Urban Total
110 Interstate: Rural Total	231 Interstate: Urban Time 1
111 Interstate: Rural Time 1	232 Interstate: Urban Time 2
112 Interstate: Rural Time 2	233 Interstate: Urban Time 3
113 Interstate: Rural Time 3	234 Interstate: Urban Time 4
114 Interstate: Rural Time 4	250 Other Freeways & Expressways: Urban Total
130 Other Principal Arterial: Rural Total	251 Other Freeways & Expressways: Urban Time 1
131 Other Principal Arterial: Rural Time 1	252 Other Freeways & Expressways: Urban Time 2
132 Other Principal Arterial: Rural Time 2	253 Other Freeways & Expressways: Urban Time 3
133 Other Principal Arterial: Rural Time 3	254 Other Freeways & Expressways: Urban Time 4
134 Other Principal Arterial: Rural Time 4	270 Other Principal Arterial: Urban Total
150 Minor Arterial: Rural Total	271 Other Principal Arterial: Urban Time 1
151 Minor Arterial: Rural Time 1	272 Other Principal Arterial: Urban Time 2
152 Minor Arterial: Rural Time 2	273 Other Principal Arterial: Urban Time 3
153 Minor Arterial: Rural Time 3	274 Other Principal Arterial: Urban Time 4
154 Minor Arterial: Rural Time 4	290 Minor Arterial: Urban Total
170 Major Collector: Rural Total	291 Minor Arterial: Urban Time 1
171 Major Collector: Rural Time 1	292 Minor Arterial: Urban Time 2
172 Major Collector: Rural Time 2	293 Minor Arterial: Urban Time 3
173 Major Collector: Rural Time 3	294 Minor Arterial: Urban Time 4
174 Major Collector: Rural Time 4	310 Collector: Urban Total
190 Minor Collector: Rural Total	311 Collector: Urban Time 1
191 Minor Collector: Rural Time 1	312 Collector: Urban Time 2
192 Minor Collector: Rural Time 2	313 Collector: Urban Time 3
193 Minor Collector: Rural Time 3	314 Collector: Urban Time 4
194 Minor Collector: Rural Time 4	330 Local: Urban Total
210 Local: Rural Total	331 Local: Urban Time 1
211 Local: Rural Time 1	332 Local: Urban Time 2
212 Local: Rural Time 2	333 Local: Urban Time 3
213 Local: Rural Time 3	334 Local: Urban Time 4
214 Local: Rural Time 4	

Note:

In addition to classification by vehicle and roadway type, the AIRS AMS structure allows the user to specify emissions for up to four time periods per day (e.g., morning peak, noon, afternoon peak, and rest of day) in order to incorporate temporal variations due to the effects of parameters, such as average speed and traffic volumes, which may vary widely depending on the time of day.

TABLE 7-2. AIRS AMS codes for offroad mobile sources (each code is 10 characters long; characters 1-2 are always "22", indicating Mobile Sources).

Characters 3 and 4	Characters 5, 6 and 7	Characters 8, 9, and 10	
60 Off-Highway Vehicle Gasoline, 2-Stroke	000 All Off-Highway Vehicle: Gasoline, 2-Stroke	000 Total	
65 Off-Highway Vehicle Gasoline, 4-Stroke	000 All Off-Highway Vehicle: Gasoline, 4-Stroke	000 Total	
70 Off-Highway Vehicle Diesel	000 All Off-Highway Vehicle: Diesel	000 Total	
60 Off-Highway Vehicle Gasoline, 2-Stroke 65 Off-Highway Vehicle Gasoline, 4-Stroke 70 Off-Highway Vehicle Diesel	001 Recreational Vehicles	000 Total 010 Motorcycles: Off-Road 020 Snowmobiles 030 All Terrain	040 Minibikes 050 Golf Carts 060 Speciality Vehicle Carts
	002 Construction Equipment	000 Total 003 Asphalt Pavers 006 Tampers/Rammers 009 Plate Compactors 012 Concrete Pavers 015 Rollers 018 Scrapers 021 Paving Equipment 024 Surfacing Equipment 027 Signal Boards 030 Trenchers 033 Bore/Drill Rigs 036 Excavators 039 Concrete/Industrial Saws	042 Cement & Mortar Mixers 045 Cranes 048 Graders 051 Off-highway Trucks 054 Crushing/Proc. Equipment 057 Rough Terrain Forklifts 060 Rubber Tire Loaders 063 Rubber Tire Dozers 066 Tractors/Loaders/Backhoes 069 Crawler Tractors 072 Skid Steer Loaders 075 Off-Highway Tractors 078 Dumpers/Tenders 081 Other Construction Equipment
	003 Industrial Equipment	000 Total 010 Aerial Lifts 020 Forklifts	030 Sweepers/Scrubbers 040 Other General Industrial Equipment 050 Other Material Handling Equipment

continued

TABLE 7-2. Concluded.

Characters 3 and 4	Characters 5, 6 and 7	Characters 8, 9, and 10	
60 Off-Highway Vehicle Gasoline, 2-Stroke 65 Off-Highway Vehicle Gasoline, 4-Stroke 70 Off-Highway Vehicle Diesel	004 Lawn & Garden Equipment	000 Total 010 Lawn mowers 015 Rotary Tillers < 5 HP 020 Chain Saws < 4 HP 025 Trimmers/Edgers/Brush Cutters 030 Leafblowers/Vacuums 035 Snowblowers 040 Rear Engine Riding Mowers	045 Front Mowers 050 Shredders < 5 HP 055 Lawn & Garden Tractors 060 Wood Splitters 065 Chippers/Stump Grinders 070 Commercial Turf Equipment 075 Other Lawn & Garden Equipment
	005 Farm Equipment	000 Total 010 2-Wheel Tractors 015 Agricultural Tractors 020 Combines 025 Balers 030 Agricultural Mowers	035 Sprayers 040 Tillers > 5 HP 045 Swathers 050 Hydro Power Units 055 Other Agricultural Equipment
	006 Light Commercial	000 Total 005 Generator Sets < 50 HP 010 Pumps < 50 HP 015 Air Compressors < 50 HP	020 Gas Compressors < 50 HP 025 Welders < 50 HP 030 Pressure Washers < 50 HP
	007 Logging Equipment	000 Total 005 Chain Saws > 4 HP 010 Shredders > 5 HP	015 Skidders 020 Fellers/Bunchers
	008 Airport Service Equipment	000 Total 005 Airport Support Equipment	010 Terminal Tractors

concluded

TABLE 7-3. AIRS AMS codes for aircraft, vessels, and locomotives (each code is 10 characters long; characters 1-2 are always "22", indicating Mobile Sources).

Characters 3 and 4	Characters 5, 6 and 7	Characters 8, 9, and 10
75 Aircraft	000 All Aircraft Types & Operations 001 Military Aircraft 020 Commercial Aircraft 050 General Aviation 060 Air Taxi 070 Aircraft Aux. Power Units 085 Unpaved Airstrips	000 Total
	900 Refueling: All Fuels	000 All Processes 101 Displacement Loss/Uncontrolled 102 Displacement Loss/Controlled 103 Spillage 201 Underground Tank: Total 202 Underground Tank: Breathing & Emptying
80 Marine Vessels, Commercial	001 Coal 002 Diesel 003 Residual Oil 004 Gasoline	000 Total, All Vessel Types 010 Ocean-Going Vessels 020 Harbor Vessels 030 Fishing Vessels 040 Military Vessels
82 Marine Vessels, Recreational	005 Pleasure Craft, Gasoline 2-Stroke 010 Pleasure Craft, Gasoline 4-Stroke 020 Pleasure Craft, Diesel	000 Total 005 Inboards 010 Outboards 015 Sterndrive 020 Sailboat Aux. Inboard 025 Sailboat Aux. Outboard
85 Railroads	002 Diesel	000 Total 005 Line Haul Locomotives 010 Yard Locomotives

7.2 CHARACTERIZATION OF ONROAD MOTOR VEHICLE EMISSIONS

The emission factors used to estimate emissions from onroad 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 onroad 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 onroad 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 and road type (see Table 7-1 for an example). In annual or seasonal inventories, emissions for each category will typically be reported as county-level totals. To facilitate accurate spatial allocation and chemical speciation of mobile source emissions, and to simplify the implementation and analysis of detailed control strategies, emissions from onroad mobile sources should be reported by both vehicle type (e.g., light-duty gasoline automobiles) and roadway classification. In addition, onroad mobile source emissions should be disaggregated into the different emissions components, such as exhaust, evaporative, running losses, etc. These three types of categorization are discussed below.

7.2.1 Vehicle Classes

The registered vehicle fleet can be divided into subgroups, or classes, such as passenger automobiles, 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 7-4, 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 two light duty gasoline truck categories (LDGT1 and LDGT2) are often combined into a single LDGT category.

7.2.2 Roadway Types

Onroad mobile source emissions should also be distinguished by road type in the inventory. Road types for which the Federal Highway Administration (FHWA) maintains statistics are listed in Table 7-5; these road types are commonly used in mobile emission inventories. Emission factors will vary by road type because of the variance in parameters such as speed and fleet distributions associated with each different road type.

TABLE 7-4. 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)	6500 to 8500 lbs.
Heavy-duty Gasoline Vehicles (HDGV)	more than 8500 lbs.
Light-duty Diesel Vehicles (LDDV)	not applicable
Light-duty Diesel Trucks (LDDT)	less than 8500 lbs.
Heavy-duty Diesel Vehicles (HDDV)	more than 8500 lbs.
Motorcycles (MC)	not applicable

† Gross Vehicle Weight

source: Reference 2

TABLE 7-5. Commonly used road type designations.

Rural and Urban Interstates
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

7.2.3 Emission Components

In addition to the categorization of onroad 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 onroad vehicle emissions are defined below:

- **Exhaust emissions**: emissions resulting from the combustion processes associated with the operation of motor vehicles. In EPA's MOBILE models, exhaust emissions are composed of three components, representing three different operating modes: cold start, hot start, and hot stabilized.

- **Evaporative emissions**: emissions resulting from the volatilization of gasoline and solvents due to rising ambient temperatures or engine heat after motor vehicle shutdown. EPA's MOBILE models (versions 4.1 and higher) recognize five components of evaporative emissions. Diurnal emissions (resulting from ambient temperature changes which occur when the vehicle is not in use), hot soak emissions (emissions that occur when fuel in the engine is vaporized by residual engine heat following vehicle shutdown), and crankcase emissions are lumped together under "evaporative." Resting loss and running loss emissions are reported separately.

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

- **Resting loss emissions**: evaporative VOC emissions from nonoperating motor vehicles that result from vapors permeating parts of the evaporative emissions control system, migrating out of the carbon canister, or evaporating liquid fuel leaks. Resting losses are distinct from diurnal emissions in that they do not result from rising ambient temperatures.

- **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 five groups, necessitating separation of the four components.

The AIRS AMS source category classifications for onroad motor vehicles (Table 7-1) do not support specification of emissions by component (e.g., exhaust, evaporative). Since this distinction must be maintained in the modeling inventory in order to adequately characterize the emissions, EPS 2.0 employs an expanded source category code classification for onroad mobile sources. The EPS 2.0 internal motor vehicle source category codes are shown in Table 7-6.

TABLE 7-6. EPS 2.0 internal source category codes for onroad motor vehicles (each source category code is 10 characters long; characters 1 and 2 are always equal to "MV").

Characters 3-4: Vehicle Class

01	Light Duty Gas Vehicles (LDGV)	05	Light Duty Diesel Vehicles (LDDV)
02	Light Duty Gas Trucks 1 (LDGT1)	06	Light Duty Diesel Trucks (LDDT)
03	Light Duty Gas Trucks 2 (LDGT2)	07	Heavy Duty Diesel Trucks (HDDT)
04	Heavy Duty Gas Vehicles (HDGV)	08	Motorcycles (MC)

Characters 5-7: Roadway Classification

000	Total: All Road Types	213	Local: Rural Time 3
001	Total: Urban	214	Local: Rural Time 4
002	Total: Suburban	230	Interstate: Urban Total
003	Total: Rural	231	Interstate: Urban Time 1
004	Total: Limited Access	232	Interstate: Urban Time 2
110	Interstate: Rural Total	233	Interstate: Urban Time 3
111	Interstate: Rural Time 1	234	Interstate: Urban Time 4
112	Interstate: Rural Time 2	250	Other Freeways & Expressways: Urban Total
113	Interstate: Rural Time 3	251	Other Freeways & Expressways: Urban Time 1
114	Interstate: Rural Time 4	252	Other Freeways & Expressways: Urban Time 2
130	Other Principal Arterial: Rural Total	253	Other Freeways & Expressways: Urban Time 3
131	Other Principal Arterial: Rural Time 1	254	Other Freeways & Expressways: Urban Time 4
132	Other Principal Arterial: Rural Time 2	270	Other Principal Arterial: Urban Total
133	Other Principal Arterial: Rural Time 3	271	Other Principal Arterial: Urban Time 1
134	Other Principal Arterial: Rural Time 4	272	Other Principal Arterial: Urban Time 2
150	Minor Arterial: Rural Total	273	Other Principal Arterial: Urban Time 3
151	Minor Arterial: Rural Time 1	274	Other Principal Arterial: Urban Time 4
152	Minor Arterial: Rural Time 2	290	Minor Arterial: Urban Total
153	Minor Arterial: Rural Time 3	291	Minor Arterial: Urban Time 1
154	Minor Arterial: Rural Time 4	292	Minor Arterial: Urban Time 2
170	Major Collector: Rural Total	293	Minor Arterial: Urban Time 3
171	Major Collector: Rural Time 1	294	Minor Arterial: Urban Time 4
172	Major Collector: Rural Time 2	310	Collector: Urban Total
173	Major Collector: Rural Time 3	311	Collector: Urban Time 1
174	Major Collector: Rural Time 4	312	Collector: Urban Time 2
190	Minor Collector: Rural Total	313	Collector: Urban Time 3
191	Minor Collector: Rural Time 1	314	Collector: Urban Time 4
192	Minor Collector: Rural Time 2	330	Local: Urban Total
193	Minor Collector: Rural Time 3	331	Local: Urban Time 1
194	Minor Collector: Rural Time 4	332	Local: Urban Time 2
210	Local: Rural Total	333	Local: Urban Time 3
211	Local: Rural Time 1	334	Local: Urban Time 4
212	Local: Rural Time 2		

Characters 7-10: Emissions Mode

EXH	Exhaust emissions	DNL	Diurnal emissions
EVP	Evaporative emissions	BG1	Exhaust emissions: Bag 1 (cold start)
RNL	Running loss emissions	BG2	Exhaust emissions: Bag 2 (hot stabilized)
RST	Resting loss emissions	BG3	Exhaust emissions: Bag 3 (hot start)
HOT	Hot soak emissions		

7.3 MOBILE SOURCE EMISSION FACTORS

The EPA's MOBILE series of models calculate VOC, NO_x, and CO emission factors for the onroad vehicle fleet. These models incorporate the data from the EPA Surveillance Program designed to quantify and characterize the emission factors encountered in the onroad vehicle fleet. The MOBILE models are run with a single input file containing both model parameters and user supplied information. Table 7-7 contains the required input parameters, and Table 7-8 lists additional optional parameters. 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.

In July 1991, EPA released MOBILE4.1, which updated the previous version of the model (MOBILE4). This is the version required for use by states in determining motor vehicle emission factors for all base year emission inventories, adjusted base year emission inventories, and CO projection inventories required by the 1990 CAAA (MOBILE4.1 does not apply to California vehicles). MOBILE4.1, which was intended as an interim version of the model which would allow states to meet the regulatory deadlines for base year SIP inventory submittal prior to the official release of MOBILE5, does not incorporate VOC and NO_x emission reductions from CAAA-mandated motor vehicle control measures, and accordingly cannot be used to project future-year emission factors without modification. MOBILE5 will include the effects of these reductions in addition to the benefits of the current Federal Motor Vehicle Control Program. A draft version of MOBILE5 has already been released, and a final version should soon be available.

7.4 MOBILE EMISSION INVENTORY PROCEDURES

In general, the emissions modeler may employ either one of two methods to develop the on-road vehicle portion of the modeling inventory:

- compiling an episode-specific onroad vehicle emission inventory using the methods described in *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*[3] (hereafter referred to as *Volume IV*); or

- adjusting an existing annual or seasonal inventory (e.g., AIRS or SAMS) to reflect episodic conditions.

The remainder of this section addresses how to determine which method is appropriate for a particular modeling application, and describes the general methodology for adjusting an existing inventory for episodic conditions.

The time requirements for developing an original inventory are not considerably greater than for developing the modeling inventory from an existing inventory, so this option is less infeasible than it

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

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

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

TABLE 7-8. Optional input parameters for EPA's MOBILE models.

Alternate basic emission rates†	
Alternate vehicle tampering rates†	
Fleet Characterization Data:	
Fleet registration distribution‡	Diesel penetration rate‡
Fleet mileage accumulation‡	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.

might first appear. Additionally, the emissions modeler may only need to generate original emissions estimates for some subcategory of the mobile fleet. Some of the primary reasons for developing an original inventory instead of adjusting an existing one include

- The motor vehicle source category classifications employed in the existing inventory are inadequate for accurate spatial, temporal, or chemical resolution of the modeling inventory, or for evaluating particular control strategies under consideration;

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

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.

For some areas, detailed transportation modeling results may be available for some portion of the modeling domain which allow onroad mobile source emissions to be estimated individually for each link of the transportation modeling network. Note the distinction between link-based emission estimation and the spatial allocation of county-level emissions using link surrogates (addressed in Section 7.3). Link-based emissions estimates incorporate actual activity data and other parameters (e.g., average vehicle speed) for each link in the transportation network; accordingly, the emissions associated with each link will vary depending on the activity for that link. When county-level emissions are spatially allocated using link surrogates, the emissions are distributed evenly over all the links of that type located in the county, based solely on the length of each link.

In EPS 2.0, the PREAM and LBASE modules serve as the entry points for county-level and link-based mobile source emissions data, respectively. The input emissions data requirements for county-level mobile source emissions data are identical to those for area source data, shown in Table 3-3. For link-based emissions data, the user must provide UTM coordinates for the beginning and end nodes of each link, the FIPS code for the county in which the link is located, the AIRS AMS source category code, and the emissions associated with each link.

Alternatively, the mobile source modeling emission inventory may be developed by adjusting an existing annual or seasonal inventory for episodic conditions. To adjust an existing inventory, the emissions modeler must duplicate the emission factors used to generate the existing mobile source inventory. Accordingly, accurate and complete information regarding the data used to generate the existing inventory is required; if necessary, contact the developer of the existing inventory to obtain this information. Some instances where the emissions modeler might choose this approach include

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

- Time constraints prevent development of an original inventory; or
- Required data such as locale-specific VMT data is not available.

The change in emissions associated with the adjustment of annual or seasonal estimates to reflect episodic conditions can be summarized by the following equation:

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

In Equation 7-1, ME refers to mobile emissions, EF represents the emission factor, the subscript "B" signifies the variables associated with the existing annual or seasonal inventory, and the subscript "E" indicates the episode-specific variables. In this equation, 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:

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

Equation 7-2 can then be incorporated into the following steps which are required to adjust the onroad mobile inventory for episodic conditions. 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 onroad 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 onroad 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.

If the existing inventory reports total VOC emissions instead of VOC emissions by component (e.g., running losses), the total VOC may be disaggregated into the emission components by applying the following fraction to the total VOC mobile source emissions:

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

where the subscript "I" refers to each emission component, and 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.

EPS 2.0 includes a utility module, MVADJ, to prepare the motor vehicle adjustment factors input file ("MADJIN") required by the PREAM, LBASE, CNTLEM, and TMPRL modules. The adjustment factors contained in the MADJIN file are used to disaggregate total motor vehicle emissions into the emission components, estimate the effects of proposed vehicle emission control strategies, and perform hourly temperature corrections. The MVADJ utility reads a series of output files from EPA's MOBILE model (versions 4.1 or 5.0) and calculates ratios of emission factors which are used to simulate each of the effects listed above. Refer to the *User's Guide for the Urban Airshed Model, Volume IV, Part A* for information regarding the MVADJ utility.

7.5 SPATIAL RESOLUTION OF MOBILE SOURCE EMISSIONS

Mobile sources differ from stationary source categories in that their spatial variation is more accurately described using a link-based rather than a surrogate-based gridding procedure. In a link-based spatial allocation approach, emissions are distributed only to those grid cells that contain transportation pathways (e.g., roadways, railways, airports, shipping channels, etc.). This approach is usually used in conjunction with a surrogate-based procedure to complete the spatial resolution of the mobile source inventory. The following section describes the methodology for spatial allocation of emissions using link data; spatial allocation of mobile emissions using gridded surrogates is discussed in Section 7.5.2.

7.5.1. Link Surrogates

Emissions from onroad vehicles on limited access roadways (interstates and expressways), railroad locomotives, aircraft, and vessels are often spatially allocated with a link-based procedure, since the transport routes used by these vehicles are both easily identifiable and readily modeled as a series of lines or links. This results in more accurate allocation of emissions from these sources than could be achieved using surrogates such as population or land use.

Figure 7-1 illustrates a typical link with respect to a portion of a modeling grid. In this example, the link, which has start and end point coordinates of (X_1, Y_1) and (X_2, Y_2), crosses three grid cells. The fraction of the total link length in each of the three grid cells, designated as ℓ_1, ℓ_2, and ℓ_3 in the figure, is easily calculated using basic trigonometric relationships. In order to spatially allocate county-level emissions using link surrogates, all of the links of a particular type (e.g., interstates or

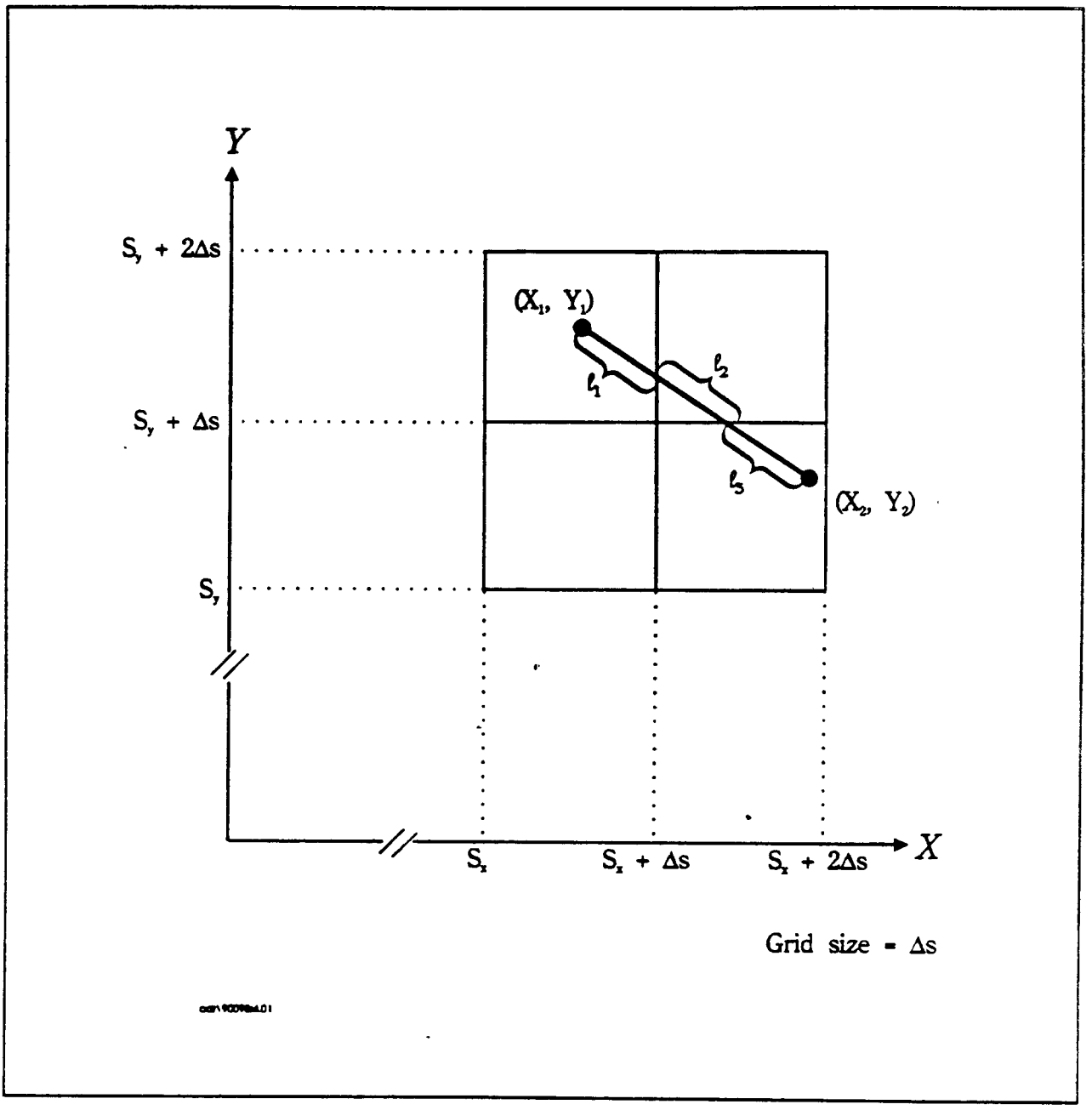


FIGURE 7-1. Depiction of typical link and grid cells.

airport runways) located within the county must be identified. For counties only partially located within the photochemical modeling domain, the links located outside of the domain must also be identified, since this information will be required to determine what fraction of the county-level emissions should be allocated to the portion of that county located within the modeling domain. After all links for a particular county have been identified, the length of each link located within each grid cell must be calculated, and the lengths summed for all links crossing that grid cell. The total length of all links of that type for the county must also be calculated, so that emissions may be allocated to grid cells as shown in Equation 7-5 below:

$$E_{(i,j)} = E_T \cdot (L_{(i,j)} / L_T) \qquad (7\text{-}5)$$

where E represents emissions, L is link length, the subscript (i,j) indicates each grid cell in the county, and T refers to the total values for the county.

The EPS 2.0 core module GRDEM automatically performs the calculations described above, given user-specified link definition data. GRDEM calculates the length of each link located within each grid cell and the total link length distance by link type for each county. The county-level emissions for the selected sources (e.g., motor vehicle travel on interstates) are then distributed to individual grid cells based on the fraction of the total link length for each county located within that grid cell.

For each link located within the counties covered by the modeling domain, the user must specify the following parameters in the optional link definition input file for the GRDEM module.

- **Type of link**: The link types currently supported by EPS 2.0 are defined as follows:
  - 101 Limited access roadways (interstates, expressways)
  - 102 Railroads
  - 103 Airports (runways)
  - 104 Shipping channels (rivers, sea lanes, ports)
  - 105 Disposal sites

  In order to redefine the existing types, or add new types, the source category/spatial allocation surrogate cross-reference glossary file must be modified to correspond to the new link type assignments.

- **County designation**: Links should be identified by county so that the total link length associated with each county can be determined. Digitized link segments should end at county borders (i.e., each link should be located entirely within a single county).

- **Beginning and end point coordinates**: The UTM Easting and UTM Northing coordinates of the endpoints of each link must be specified in meters.

The first step in determining the parameters required for specifying link surrogates is to obtain a map identifying the appropriate transportation pathways. The U.S. Geologic Survey (USGS) maps, which are readily available in a variety of scales, clearly indicate railroads, airport runways, rivers, and ports. In addition, the USGS maps reference locations using both UTM coordinates and latitude and longitude in degrees, simplifying the conversion of link locations to the modeling coordinate system. More detailed street maps, however, may be required to identify different motor vehicle roadway types. Since no standard coordinate system is usually identified on street maps, several reference points on the street map must be identified whose coordinates are known or can be determined from a USGS map in order to convert the street map locations to the modeling coordinate system. County line intersections make particularly good reference points, since they are clearly marked on most street maps.

To facilitate the determination of the link coordinates, it is highly recommended that an 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 the 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 the digitizer board in a fixed position and moving the sensor to each link start and end point location. In addition, two reference points must be digitized to provide the information required to convert the digitizer coordinate system to the coordinate system of the modeling region.

7.5.2 Non-link Mobile Emission Spatial Surrogates

Non-link surrogates are commonly used to spatially allocate mobile emissions in the following situations:

- Links are too numerous to define and process, as is typically the case for onroad rural and urban vehicles and for offroad vehicles.

- Emission totals are too insignificant when compared with emissions from other sources in the modeling domain to warrant the development of link data.

- Use of gridded spatial surrogates based on landuse or population data provides a more accurate allocation of vehicle emissions. For example, recreational boating activities may be distributed approximately equally over the surface of a large lake.

The procedure for the allocation of emissions using landuse data is identical to that outlined in Section 6.2.2.

In most modeling applications, a combination of link and landuse surrogates is used for the spatial allocation of mobile source emissions. As an example, Figure 7-2 shows the links identified for a

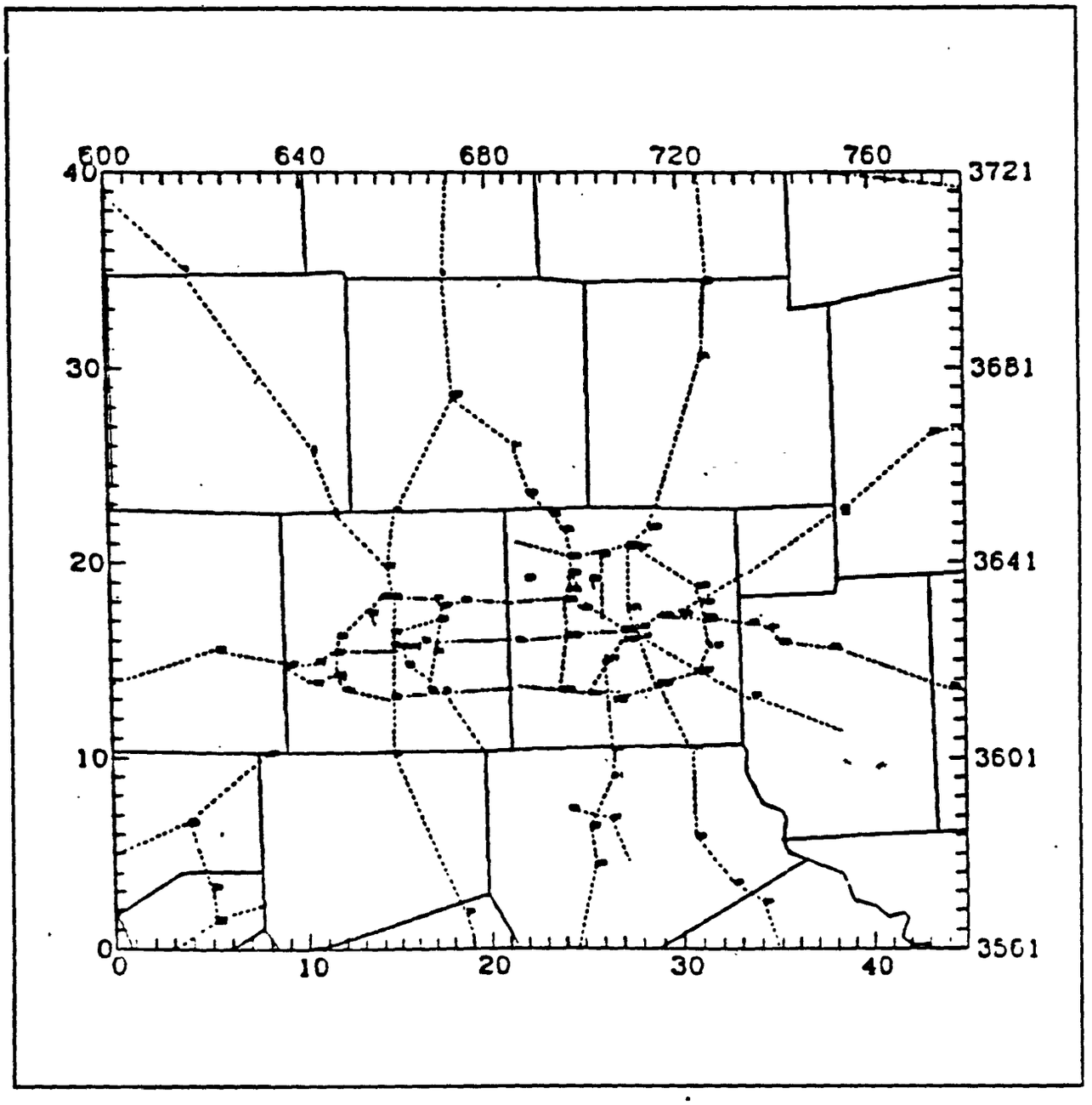


FIGURE 7-2. Onroad mobile source link surrogates developed for a UAM application of the Dallas/Fort Worth region.

UAM application for the Dallas/Fort Worth area. In this figure, 131 links were defined for the allocation of emissions from limited access roadways and commercial airports. Figure 7-3 shows the gridded onroad mobile source inventory for this area, which was prepared using urban and rural landuse surrogates for those source categories for which links were not developed.

The default source category/spatial allocation surrogate cross-reference glossary file provided with the EPS 2.0 contains the following assignments for onroad mobile sources:

AIRS roadway classification	Spatial allocation surrogate
Interstates (both urban and rural)	Limited access roadways (link type 101)
All other urban road classifications	Urban landuse
All other rural road classifications	Rural landuse

Unless the user modifies this file, EPS 2.0 will use these surrogates to spatially allocate emissions from onroad mobile sources.

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); see Figures B-x and B-y in Appendix B, which show the default weekday and weekend diurnal variation profiles assumed by EPS 2.0 for onroad mobile sources, for an example. Accordingly, the emissions modeler should be careful to select a diurnal variation pattern for onroad 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.

As discussed in Section 6.3, the TMPFAC utility of EPS 2.0 will construct source category-specific temporal variation profiles for each county based on the information contained in the AMS workfile-formatted input emissions data. In the absence of such data, EPS 2.0 will use the temporal profiles assigned to the onroad mobile source categories in the source category/temporal profiles cross-reference system input file. The default profile assignments in this file (refer to Appendix C for profile definitions) for all onroad mobile source categories are

Monthly variation: Profile 1 (no variation by month)
Weekly variation: Profile 13 (weekend activity equal to 75% of weekday levels)
Diurnal variation: Profile 50

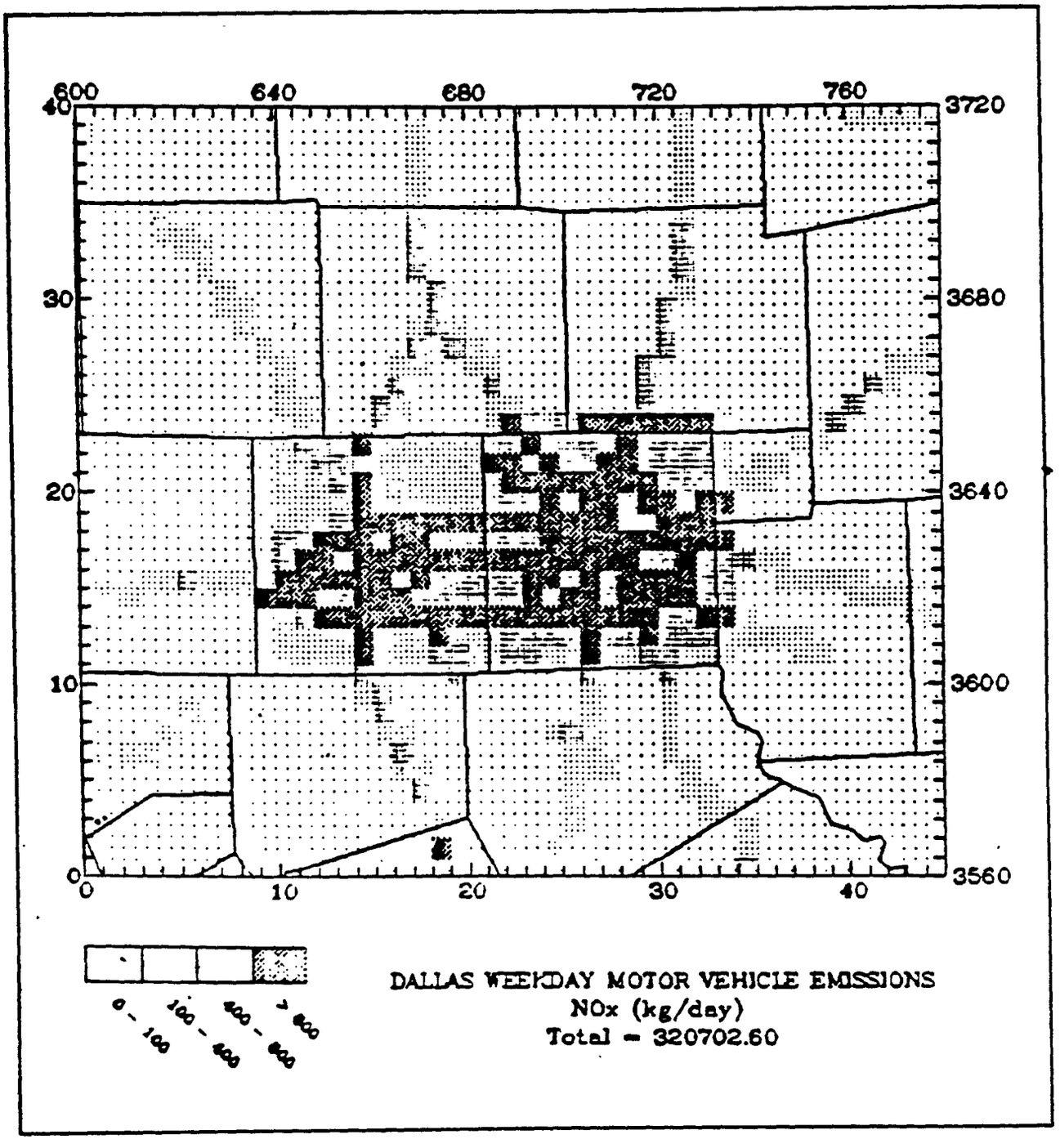


FIGURE 7-3. Gridded annual average onroad mobile source emissions for a UAM application of the Dallas/Fort Worth region.

For each region modeled, these defaults should be reviewed to assess their applicability for that region. Note that the assumption of no monthly variation of onroad mobile emissions is not characteristic of any particular region, but is an indication of the wide variance of monthly variation depending on location. Data describing monthly variations in VMT may be directly incorporated into the calculations described in Section 7.3, or may be used to develop region-specific monthly temporal profiles for the onroad mobile source categories.

7.7 MOBILE SOURCE PROJECTIONS

Future-year emissions estimates for onroad mobile sources must incorporate anticipated changes in vehicle activity (i.e., VMT) as well as in the vehicle fleet itself. As more and more older, higher emitting vehicles are phased out of service and replaced with new vehicles, the average emission rate for the fleet decreases, although this effect is partially offset in most areas by increased activity. In addition, changing regulations (federal, state and local) affecting the onroad vehicle fleet, such as new vehicle emission standards and various control measures required under the 1990 Clean Air Act Amendments, must also be addressed. Consult Sections III.E and IV.D of *Procedures for Preparing Emissions Projections* (EPA, 1991) for additional guidance.

7.7.1 VMT Projections

EPA has published several documents which provide guidance for the estimation of future year motor vehicle activity. In addition to the document cited above, the *Section 187 VMT Forecasting and Tracking Guidance* document, developed to provide guidance for those areas required to submit ozone or carbon monoxide State Implementation Plans, describes EPA's recommended methods for developing future year VMT estimates for these areas. The preferred method involves the use of a zonal-based travel demand model which has been validated using 1985 or more recent ground counts. Alternatively, short term VMT projections can be based on Federal Highway Administration's Highway Performance Monitoring System (HPMS) (U.S. DOT, 1987). For areas located outside of the travel demand modeling domain and/or the HPMS reporting area, EPA permits use of any reasonable method for forecasting VMT.

Transportation Control Measures (TCMs). TCMs consist of a wide array of control measures which are designed for the reduction of traffic activity and/or congestion. TCMs are being studied and implemented in many CMSAs. Incorporation of TCMs into the modeling emission inventory requires that either a VMT reduction or speed adjustment factor be estimated for each TCM. If a speed adjustment factor is used to characterize the effectiveness of the TCM, an associated emissions reduction may be estimated using the MOBILE emission factor model.

7.7.2 Future-Year Emission Factors

As discussed in Section 7.3, MOBILE4.1 does not incorporate VOC and NO_x emission reductions from CAAA-mandated motor vehicle control measures and thus cannot be used to project future-year emission factors. Once the final version of MOBILE5 becomes available, it should be used to prepare future year onroad mobile source emission inventories instead of earlier versions, since MOBILE5 addresses the new control requirements. The following paragraphs summarize some future-year conditions that may need to be modeled, and recommend methods for addressing these conditions in the emission factor calculations.

Fuel Oxygenate Additives. In the past, oxygenates such as methyl tertiary butyl ether (MTBE) and ethanol have been added to fuel in winter months to reduce CO emissions; the use of these additives, however, has become sufficiently widespread that fuel oxygenates are beginning to be used all year. Since oxygenates generally lower exhaust VOC emissions and raise evaporative VOC emissions, determining fuel oxygen content for both the base and future modeling years is important. CO reductions due to oxygenates can be modeled using a specialized version of the MOBILE model called OXY4. OXY4 is available from EPA OMS, 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 require that ozone nonattainment areas implement a variety of regulations addressing onroad motor vehicles, including the following:

- Vehicle inspection and maintenance programs;
- Stage II refueling vapor recovery programs;
- Fuel reformulation (including Reid Vapor Pressure (RVP) limits, fuel additives, and fuel composition); and
- New vehicle emission certification standards (will be incorporated into MOBILE 5.0).

The first two of these requirements can be modeled directly with the MOBILE models. For fuel reformulation effects, the MOBILE models address the effect of RVP limits; consult Reference 4 for guidance regarding fuel additive effects. In general, changes in fuel composition changes do not affect emission factors, but will affect the chemical speciation of VOC emissions (Chapter 9).

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 Manual for the Emissions Preprocessor System 2.0, Part A: Core FORTRAN System*, EPA-450/4-90-007D (R), U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, May 1992.

6. *Procedures for Preparing Emissions Projections*, EPA-450/4-91-019, U.S. Environmental Protection Agency (OAQPS), July 1991.

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 species are quite photochemically reactive (e.g., isoprene). Accordingly, the modeling inventory must include some estimate of biogenic emissions for completeness.

In a collaborative effort, researchers at Washington State University and EPA developed a computerized system to estimate hourly gridded biogenic emissions, called the Biogenic Emissions Inventory System (BEIS). To support different inventory and modeling input requirements, several versions of the BEIS model are available, including PC-BEIS (which runs on a personal computer and estimates county-level biogenic emissions), ROM-BEIS (for Regional Oxidant Model applications), and UAM-BEIS (for Urban Airshed Model applications). Although the remainder of this section focuses on the specifics of the UAM-BEIS, similar methodologies are employed in each version.

Several changes to the original version of the UAM-BEIS have recently been implemented, including (1) a more accurate algorithm for calculating solar energy; (2) a new algorithm to calculate soil NO_x emissions and a conversion factor correction; and (3) additional capabilities for processing user-supplied county-level or gridded land use data. The current version, UAM-BEIS Version 1.1, is available to the public from EPA. The following overview of the BEIS is taken from information contained in the paper "Development of a Biogenic Emissions Inventory System for Regional Scale Air Pollution Models"[1] and in Section 8 of the *User's Guide for the Urban Airshed Model, Volume IV: User's Manual for the Emissions Preprocessor System 2.0, Part A: Core FORTRAN System.*[2]

8.2 OVERVIEW OF THE UAM-BEIS

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

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

where ER is the emission rate, i indicates each chemical species (e.g., isoprene or monoterpene), j indicates vegetation type, BF is a biomass density factor, EF is the biogenic emission factor, and F(S,T) is an environmental factor accounting for solar radiation (S) and leaf temperature (T). Each of

the variables in Equation 8-1 are discussed below, followed by a brief description of the processing methodology employed by the UAM-BEIS.

The UAM-BEIS produces one output file, a binary UAM-format low-level emissions file. This file contains hourly gridded biogenic emission rates (which have been corrected for episode-specific environmental conditions) for olefins, paraffins, isoprene, aldehydes, NO, and NO_2. This file may be used directly as input to UAM or merged with the UAM low level anthropogenic emissions file using EPS 2.0.

8.2.1 Leaf Biomass Factors

The default leaf biomass data base provided with the UAM-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 areal coverage for different types of forests, agricultural crops, and other areas such as grasslands and water. Alternatively, UAM-BEIS will estimate emissions using user-specified county-level or gridded land use data for the 25 vegetation types listed in Table 8-1. Note that although water area is included in the default data base provided with UAM-BEIS, and is a required field in the optional user-specified county-level or gridded land use data files, UAM-BEIS does not currently estimate aquatic natural emissions. It is expected that future versions of the UAM-BEIS model will include this calculation, so the water area data field has been maintained in the input land use data file structures.

Each of the forest types in the land use data base is assigned to one of three forest groups: oak forest, other deciduous forest, and coniferous forest. 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 8-2 shows the biomass density factors assumed by UAM-BEIS for each emission category for the three forest groups. The UAM-BEIS seasonally adjusts biomass based on the frost dates for each county using a simple step function. For each month, deciduous vegetation within a county is assumed to have 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 UAM-BEIS are based largely on Zimmerman's study of biogenic emission rates in the Tampa/St. Petersburg Florida area.[3] Emissions are calculated for four hydrocarbon species: isoprene, α-pinene, other monoterpenes, and other nonmethane hydrocarbons. 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). The UAM-BEIS processes canopy vegetation types and non-canopy vegetation types. For forest types (i.e., oak, other deciduous, and coniferous forests), UAM-BEIS estimates emissions for each forest emission category using the factors shown in Table 8-4. Emissions for non-forest vegetation types are estimated from areal coverage by land use type using the emission rates given in Table 8-5.

TABLE 8-1. Vegetation types employed by the UAM-BEIS for user-specified county-level or gridded land use data.

Canopy Land Use Types

1	Oak forest	2	Deciduous forest	3	Coniferous forest

Non-Canopy Land Use Types

4	Urban oak	12	Potato	19	Barley
5	Urban deciduous	13	Tobacco	20	Oats
6	Urban coniferous	14	Wheat	21	Scrub
7	Alfalfa	15	Cotton	22	Grass
8	Sorghum	16	Rye	23	Urban grass
9	Hay	17	Rice	24	Miscellaneous crops
10	Soybean	18	Peanut	25	Water
11	Corn				

source: Reference 2

TABLE 8-2. Biomass density factors (g/m^2) by forest group for each emission category.

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

Chemical Species	Carbon Bond 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

TABLE 8-4. Biogenic emission factors (μg/g/h) by forest emission category used by UAM-BEIS for canopy vegetation types and urban trees (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 8-5. Emission rates ($\mu g/m^2$-hr) and chemical speciation employed by UAM-BEIS for non-canopy land use types (except urban trees).

Non-Canopy Land Use Type	Emission Rate ($\mu g/m^2$-hr)	Percent of Emission Rate by Chemical Species			
		Monoterpenes	α-Pinene	Isoprene	Other
7 Alfalfa	37.9	10	10	50	30
8 Sorghum	39.4	25	25	20	30
9 Hay	189.0	25	25	20	30
10 Soybean	22.2	0	0	100	0
11 Corn	0.5	10	10	0	80
12 Potato	48.1	25	25	0	50
13 Tobacco	294.0	10	10	0	80
14 Wheat	30.0	10	10	50	30
15 Cotton	37.9	25	25	20	30
16 Rye	37.9	25	25	20	30
17 Rice	510.0	25	25	20	30
18 Peanut	510.0	25	25	20	30
19 Barley	37.9	25	25	20	30
20 Oats	37.9	25	25	20	30
21 Scrub	189.0	25	25	20	30
22 Grass	281.0	25	25	20	30
23 Urban grass	281.0	25	25	20	30
24 Miscellaneous crops	37.9	25	25	20	30

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. The previous version on UAM-BEIS estimated soil NO_x emissions from grasslands only. The current version, UAM-BEIS 1.1, has been modified to estimate NO emissions for forest, agricultural crops, and urban trees as well as grasslands; additional changes include an increase to the NO emission factor for grasslands, the removal of NO_2 emissions, and the correction of a conversion factor. UAM-BEIS calculates soil NO emissions using the following equation:

$$F_{NO} = A \cdot \exp(0.071\ T_s) \qquad (8\text{-}2)$$

In Equation 8-2, F_{NO} is the NO flux in units of ng Nitrogen/m^2-s, T_s is the soil temperature in Celsius, and A is a constant equal to 0.9 for grasslands and pasture, 0.07 for forests and urban trees, and 0.2 for agricultural croplands.

8.2.3 Environmental Correction 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 UAM-BEIS are standardized for full sunlight and 30° Celsius. The UAM-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 8-1.

BEIS also simulates the vertical variation of leaf temperature and sunlight within the forest canopy. The canopy model employed by UAM-BEIS assumes that sunlight decreases exponentially through the hypothetical forest canopy; the rate of attenuation depends on the assumed biomass distribution. Figure 8-2 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 8-3 presents the assumed temperature and solar flux variation by canopy layer for deciduous and coniferous forests.

8.2.4 Processing Methodology

UAM-BEIS calculates the emission rates of α-pinenes, other monoterpenes, isoprene, and other nonmethane hydrocarbons by multiplying biomass for each vegetation type by the appropriate emission factors. The calculated emission rates are then adjusted for specific environmental conditions of the modeling episode using data from the user-supplied meteorology file and the output files of the temperature and winds UAM meteorology preprocessors. Corrections are performed for

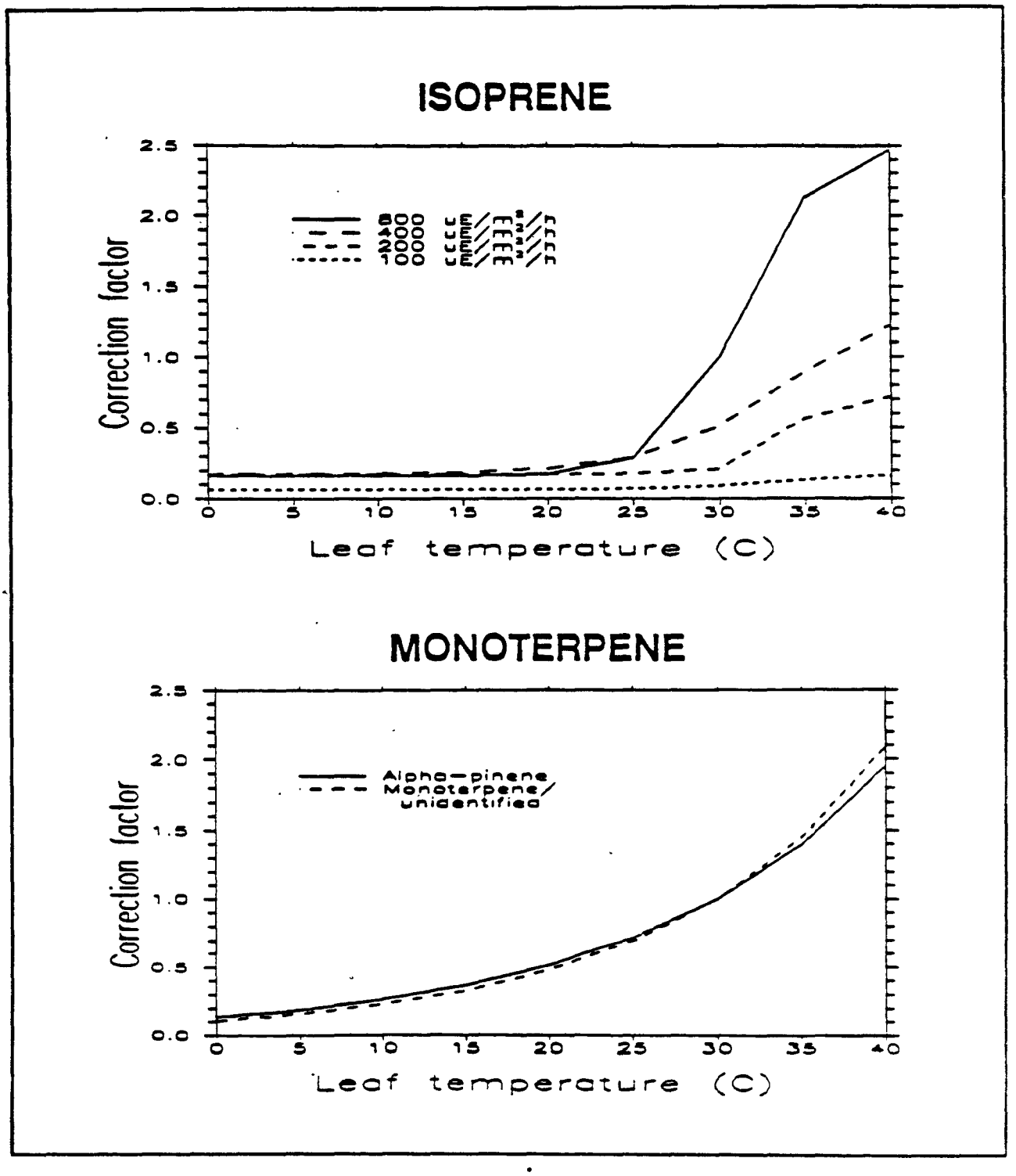


FIGURE 8-1. Biogenic emission factor sensitivity to leaf temperature.

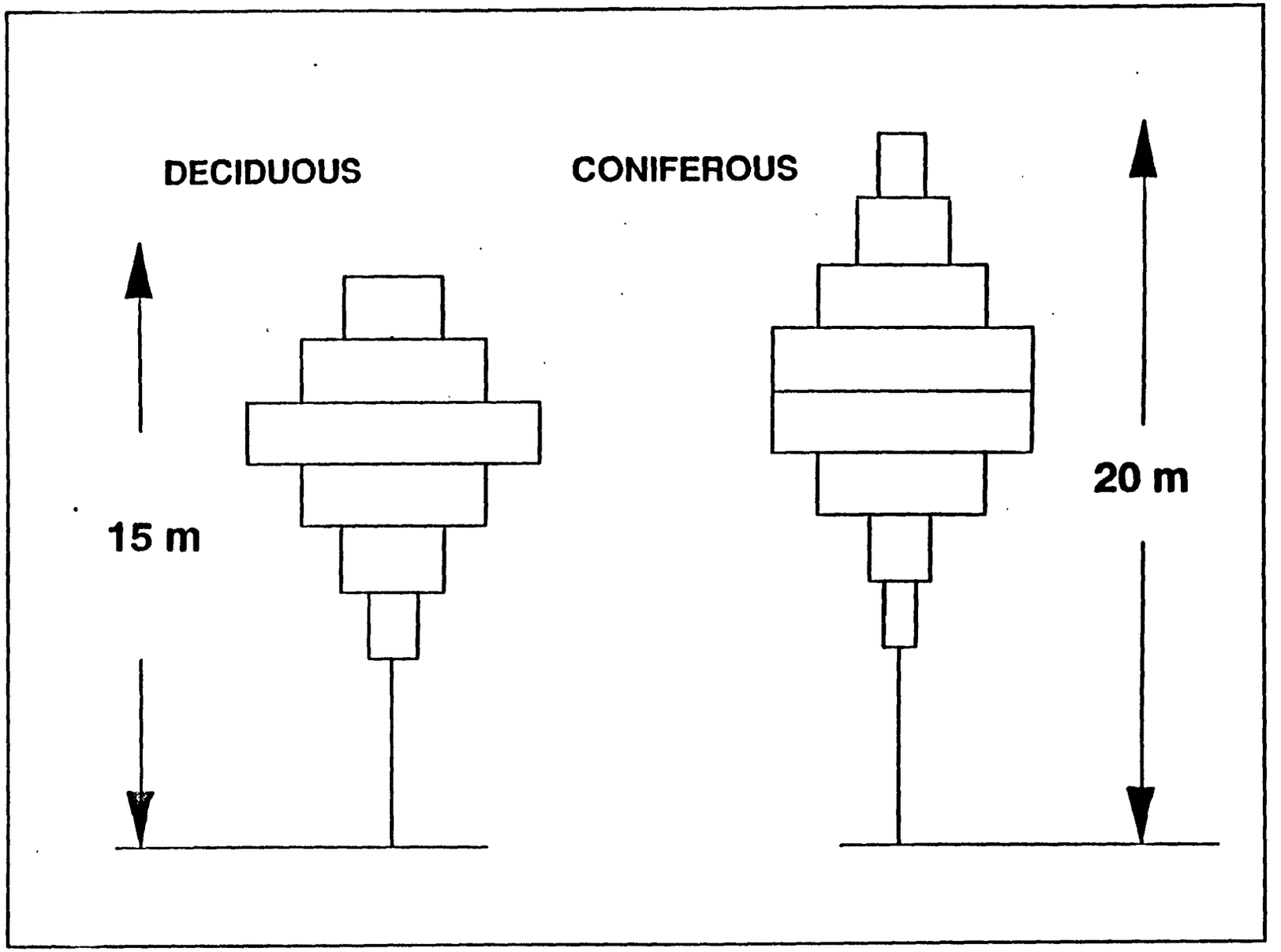


FIGURE 8-2. Schematic representation of forest canopy types.

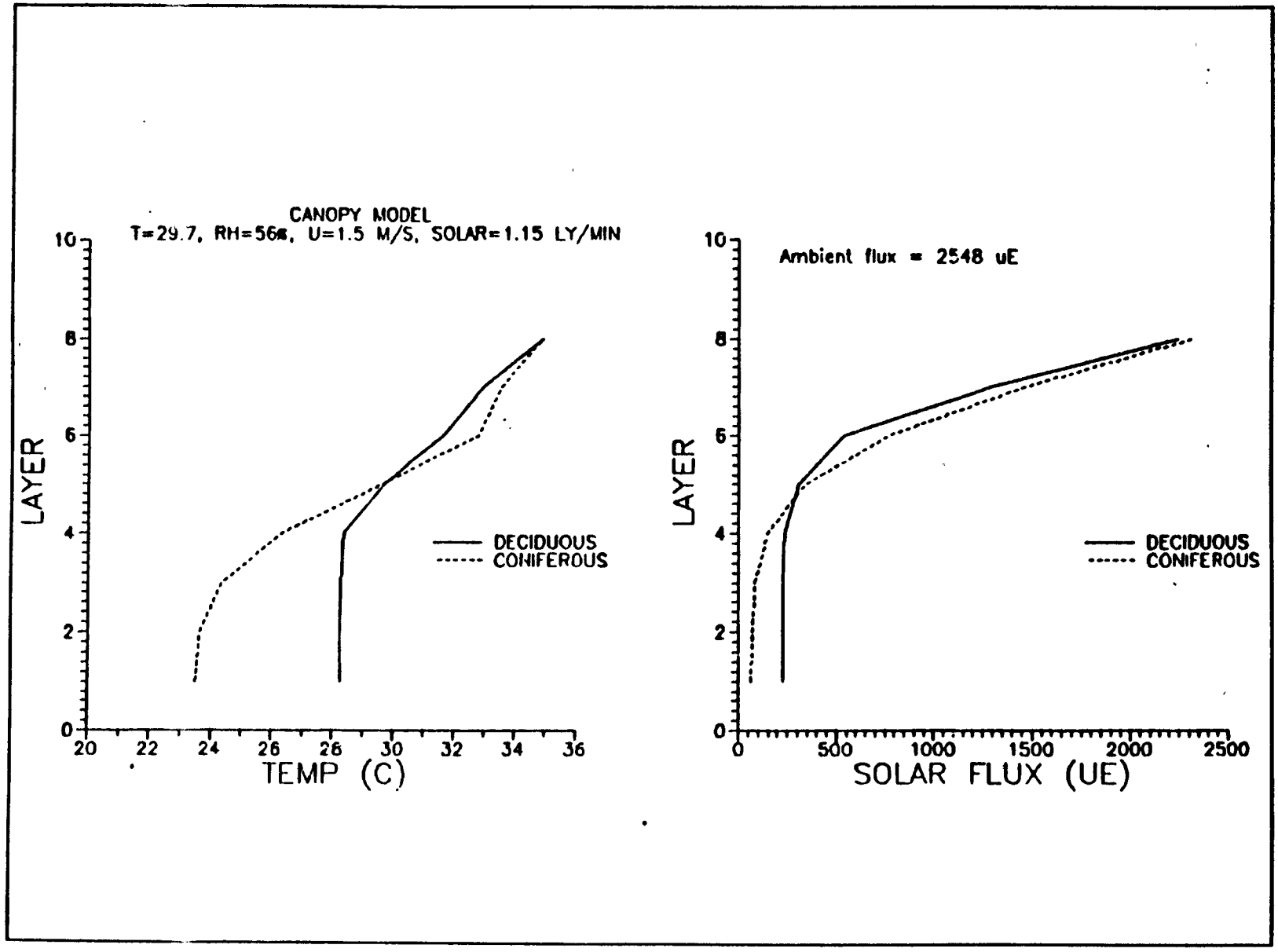


FIGURE 8-3. Temperature and solar flux variations by canopy layer.

each grid cell of the modeling domain using the hourly, gridded temperature and surface wind speed fields data contained in these two UAM input files.

For forested areas, land use area data for each county are multiplied by biomass density factors for each forest type. EPA provides a default land use/biomass data file for use with UAM-BEIS which contains county-level land use area for each of the 25 vegetation types listed in Table 8-1. The calculated county-level biomass is gridded using a county allocation file, which indicates the percentage of each grid cell occupied by a particular county. If more current land use data are available, the user may include these data by using the optional gridded land use data file or the optional county-level land use data file. The next step in processing forested areas involves adjusting the emission rates for temperature and solar energy changes within the forest canopy. The adjusted emission rates are then grouped into categories for five Carbon Bond Mechanism IV (Gery et al., 1989) species (olefins, paraffins, isoprene, aldehydes, and nonreactives) and nitric oxide (NO). Although UAM-BEIS calculates emission rates for nonreactive hydrocarbons, it does not output this information because it is not used by UAM.

Nonforested areas, or noncanopy areas (including agricultural areas and urban trees), are handled a bit differently. The land use data found in the land use/biomass file is multiplied by an on/off flag (also found in this file) to indicate whether the vegetation is growing or not for the episode month. Next the data are gridded using the county allocation file. Land use is then multiplied directly by an emission factor to produce emission rates. Speciation and environmental adjustments are handled the same as for forested areas, except that the nonforest emission rates are not adjusted for canopy effects.

8.3 UAM-BEIS INPUT REQUIREMENTS

As indicated above, the UAM-BEIS uses three types of data files: UAM preprocessor data, user-supplied data, and data supplied to the user by EPA. Figure 8-4 shows a flow chart of the UAM-BEIS flow of information. Each of the input data files is briefly described below. Section 8 of the *User's Guide for the Urban Airshed Model, Volume IV: User's Manual for the Emissions Preprocessor System 2.0, Part A: Core FORTRAN System*[2] contains detailed format descriptions of the various input files.

UAM Preprocessor Data. Two of the UAM preprocessor files are also used by UAM-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. In addition, Version 1.1 of the UAM-BEIS allows the user to specify land use data, either

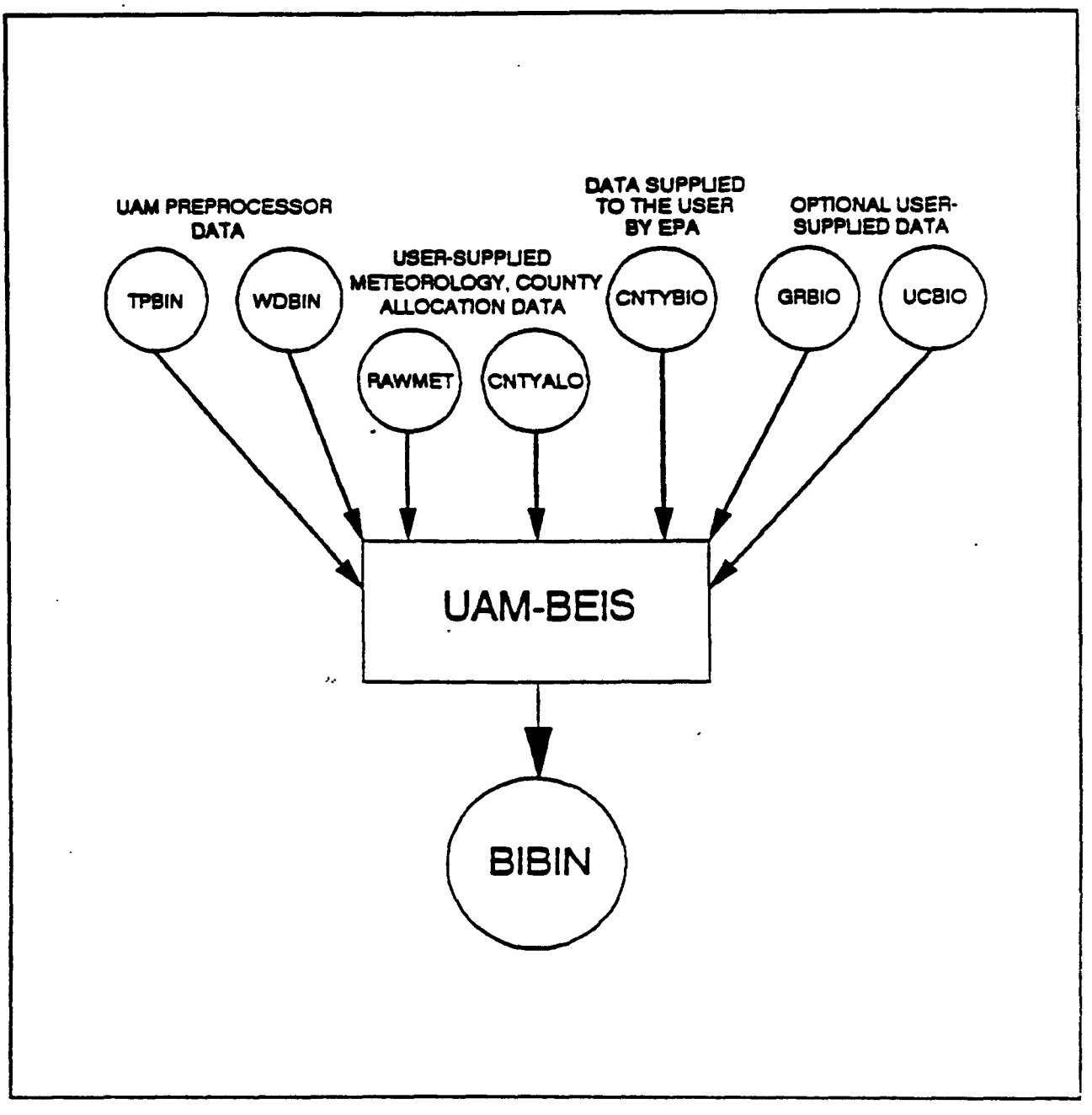


FIGURE 8-4. UAM-BEIS input and output files.

county-level or for each grid cell of the modeling domain. Each of these files are described briefly below:

RAWMET — The meteorology file RAWMET contains hourly surface meteorological information on relative humidity, cloud coverage, and cloud height for one station in the user's UAM domain. The file is created by the user with data which may be obtained from the National Weather Service.

CNTYALO — The county allocation file contains the percentage of each grid cell that a given county occupies. To speed processing, this file should be sorted by FIPS code. The CNTYALO file may be created by the user; however, the EPA has a Gridded Surrogate/County Allocation Utility which will create the file given the UAM domain coordinates and grid cell size. To request this data, contact the nearest EPA Regional Office.

GRBIO — If the user wishes to use more up-to-date land use data which are already gridded, the optional gridded land use file, GRBIO, may be used. For each grid cell, the user must input values in hectares for the 25 land use types used by UAM-BEIS.

UCBIO — If the user has more up-to-date land use data on a county level, the optional county land use file, UCBIO, may be used. For each FIPS code, the user must input values in hectares for the 25 land use types used by UAM-BEIS.

In addition to the user-supplied data files listed above, the user must supply certain input control data required by UAM-BEIS, consisting of domain and scenario-specific information along with control option flags. The user must input start date and hour, end date and hour, month of scenario, number of columns and rows, number of hours from Greenwich Mean Time (GMT) to local time, number of counties, and a list of counties. Three flags which control several options in UAM-BEIS must also be set by the user. The first flag, called GIFLAG, must be set to TRUE if the user wishes to input his own gridded land use data using the optional GRBIO file. The second flag, called CFLAG, must be set to TRUE if the optional UCBIO file is being used to input the user's own county land use data. The third flag, called GROWFLAG, must be set if the user inputs gridded land-use data. This flag is set to TRUE to indicate that vegetation is growing and FALSE if only coniferous vegetation is growing, which might be the case in a cold season like late fall or winter.

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, 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 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. T. E. Pierce, B. K. Lamb, and A. R. Van Meter, "Development of a Biogenic Emissions Inventory System for Regional Scale Air Pollution Models", 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 Manual for the Emissions Preprocessor System 2.0, Part A: Core FORTRAN System*, EPA-450/4-90-007D (R), U.S. Environmental Protection Agency (OAQPS), Research Triangle Park, NC, May 1992.

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, NO_x 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 (CBM-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 CBM-IV contains over 80 reactions and more than 30 species. These reactions and species are tabulated in Appendix A of the *User's Guide for the Urban Airshed Manual, Volume I.*[1]

The differential equations that describe the CBM-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 CBM-IV version of the UAM.

In EPS 2.0, 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 carbon monoxide (CO) should also be included in the UAM modeling inventory, since CO is a photochemically reactive species.

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

TABLE 9-1. CBM-IV chemical species recognized by the UAM system, with molecular weights (grams per mole) for unit conversion.

UAM Species	Species Name	Molecular Weight
Default species supported by EPS 2.0:		
NO	Nitric oxide	30
NO2	Nitrogen dioxide	46
CO	Carbon monoxide	28
SO2	Sulfur dioxide	64
AERO	Aerosols (particulates)	1
PM10	Particulate matter, diameter $\leq$ 10 microns	1
OLE†	Olefinic carbon bond (C=C)	32
PAR†	Paraffinic carbon bond (C—C)	16
TOL†	Toluene (C_6H_5—CH_3)	112
XYL†	Xylene (C_6H_6—$(CH_3)_2$)	128
FORM†	Formaldehyde (CH_2=O)	16
ALD2†	High molecular weight aldehydes (RCHO, R$\neq$H)	32
ETH†	Ethene (CH_2=CH_2)	32
MEOH†	Methanol (optional)	16
ETOH†	Ethanol (optional)	32
ISOP†	Isoprene	80
Other species:		
O3	Ozone	48
O2	Oxygen	32
H2O	Water	18
CO2	Carbon dioxide	44
CH4	Methane	16
TOTAL HC	Total hydrocarbons	16
OXIDANT	Photochemical oxidant	48
SO4	Sulfate	96
CRES	Cresol and higher molecular weight phenols	128
MGLY	Methyl glyoxal ($CH_3C(O)C(O)H$)	72
OPEN	Aromatic ring fragment acid	86
PNA	Peroxynitric acid (HO_2NO_2)	79
NOX	Total nitrogen oxides ($NO + NO_2 + N_2O_5 + NO_3$)	46
SOX	Total sulfur oxides	64
PAN	Peroxyacyl nitrate ($CH_3C(O)O_2NO_2$)	121
HONO	Nitrous acid	47
H2O2	Hydrogen peroxide	34
HNO3	Nitric acid	63

† Default molecular weight for carbon bond species derived from hydrocarbons is the carbon number multiplied by the molecular weight of methane.

source: Reference 1

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 bond class, in this case 2, 5, and 3 tons per day, respectively.

This allocation step would, of course, have to be performed for each emission total 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 CBM-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).

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 CBM-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 CBM-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 EPA's *VOC/PM Speciation Data Base Management System (SPECIATE).*[2] The SPECIATE data base contains over 250 VOC "emission profiles" like the example in Table 9-2 for various point and area source categories; the data base also contains profiles for emissions from motor vehicles and aircraft. In each profile, individual chemical compounds are

TABLE 9-2. Example VOC speciation profile from the *SPECIATE* data base

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	142-28-5	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

listed with their corresponding molecular weights and weight percentage of the mixture. (The EPA speciation profile codes and descriptions are listed in Appendix C).

The type of information contained in Table 9-2 can be used with the CBM-IV species 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

$$\text{split factor for each CBM species i} = \Sigma_j \left[(WF_j / MW_j) \cdot (\text{moles of } i \text{ / mole } j) \right] \qquad (9\text{-}1)$$

where i is the CBM-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 speciation data are unavailable, the emissions modeler can use the speciation profiles contained in the SPECIATE database (with the CBM-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.

EPS 2.0 includes an input file preparation utility, called EMSCVT, which will create the split factors and SCC(ASC)/speciation profile cross reference files required by the CHMSPL module (which converts criteria pollutant emissions into CBM-IV species). The split factors file consists of multiplicative factors for converting grams of criteria pollutant emissions into moles of CBM-IV species for each speciation profile. The SCC(ASC)/speciation profiles cross-reference file contains the speciation profile code assignments by SCC code for point sources and by Area Source Category (ASC) code for area and mobile sources; this file may also contain source-specific speciation profile assignments. The user may either generate completely new versions of these files or update the existing versions. EMSCVT calculates the split factors for each speciation profile based on the weight fractions of the individual chemical compounds associated with that profile and the carbon bond speciation for each compound, as described above. The EMSCVT utility has been designed to allow the user to easily incorporate source-specific speciated emissions data, if such data are available.

The EMSCVT utility will produce split factors to disaggregate either total or reactive VOC, depending on the value specified for a user input flag. The split factors used to speciate emissions must be compatible with the way emissions have been reported in the inventory (e.g., if emissions have been reported as total VOC, the split factors must be calculated for total VOC also). See Section 9.6 for more on this topic.

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.

Unless the user has explicitly included source- or source category-specific split factors for speciating NO_x emissions in the split factors file, the CHMSPL module will use default split factors for all sources, which assume 90% and 10% by weight of NO (as NO_2) and NO_2, respectively.

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. For example, if split factors for total VOC were to be applied (erroneously) to RVOC emissions estimates, the resulting emission estimates in each VOC class

would be potentially underestimated, since a specified nonreactive fraction of the emissions would be subtracted before allocation of the reactive portion to carbon bond classes.

Converting the split factors from a total VOC to an RVOC basis is a relatively simple procedure that involves recalculating the average molecular weight of the mixture without the nonreactive components (in most cases, primarily methane); the methane-free molecular weight may then be used with the CBM-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 utilizes some sort of species 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 split 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 EPS 2.0 is being used to develop the modeling inventory, emissions from onroad motor vehicles will already have been disaggregated into exhaust and evaporative (consisting of diurnal, refueling, and running loss components) by the PREAM or LBASE modules.

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.*[6]

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

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

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.

  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:

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APPENDIX A:

ACRONYMS AND GLOSSARY

ACRONYMS AND ABBREVIATIONS

AEROS	Aerometric and Emissions Reporting System
AIRS	Aerometric Information Retrieval System
AFS	AIRS Facility Subsystem
AMS	Area and Mobile Subsystem (of AIRS)
ASC	AIRS Source Category (used to identify area and mobile source categories)
ATP	Anti-tampering program
BACT	Best Available Control Technology
BEA	Bureau of Economic Analysis
BEIS	EPA's Biogenic Emissions Inventory System
CBM	Carbon Bond Mechanism
CMSA	Consolidated Metropolitan Statistical Area
CO	Carbon monoxide
CTG	Control Technique Guideline
EMAR	Emissions Model ASCII Record
EMBR	Emissions Model Binary Record
EPA	Environmental Protection Agency
EPS	Urban Airshed Model Emissions Preprocessor System
FIP	Federal Implementation Plan
FIPS	Federal Information Processing Standards
FMVCP	Federal Motor Vehicle Control Program
FTP	Federal Test Procedure (for motor vehicles)
HDGV	Heavy duty gasoline vehicles
I/M	Inspection and maintenance program
JCL	Job Command Language
LDGV	Light duty gasoline vehicles

LDGT	Light duty gasoline trucks
MACT	Maximum Available Control Technology
MDGV	Medium duty gasoline vehicles
MSA	Metropolitan Statistical Area
NAAQS	National Ambient Air Quality Standard
NAPAP	National Acid Precipitation Assessment Program
NEDS	National Emission Data System (superseded by AIRS)
NO_x	Nitrogen oxides
O_3	Ozone
OAQPS	EPA's Office of Air Quality Planning and Standards
RACT	Reasonably Available Control Technology
RHC	Reactive hydrocarbons
ROM	Regional Oxidant Model
RVOC	Reactive Volatile Organic Compounds
RVP	Reid vapor pressure
SAMS	SIP Air Management System
SAROAD	Storage and Retrieval Air Quality Data code (superseded by AIRS)
SCC	Source Classification Code
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SMSA	Standard Metropolitan Statistical Area
SO_x	Sulfur oxides
THC	Total hydrocarbons
TNMHC	Total nonmethane hydrocarbons
TSP	Total suspended particulate matter
UAM	Urban Airshed Model
USGS	United States Geological Survey
VMT	Vehicle miles traveled
VOC	Volatile organic compounds

GLOSSARY

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

Actual emission inventory
An emission inventory which represents the actual emission rates over the specified time interval for each source.

Adjusted base year inventory
The base year inventory minus (1) biogenic emissions, (2) emission reductions from Federal Motor Vehicle Control Program (FMVCP) regulations promulgated prior to 1 January 1990, (3) emissions reductions from RVP rules promulgated prior to 1990 Clean Air Act Amendment (CAAA) enactment or required under CAAA Section 211(h), and (4) any sources outside of the nonattainment area. Required for ozone nonattainment areas ranked moderate, serious, severe, and extreme.

Allowable emission inventory
An emission inventory which represents maximum allowable emission rates for each source. Allowable emission rates may be based on emission factor limits, activity level limits, or both.

Annual average daily emissions
The average daily emission rate from a particular source or source category, calculated by dividing the annual emissions for that source by 365 days per year.

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

Area 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 small or numerous to be handled individually in the point source inventory.

Base year inventory
A comprehensive and accurate inventory of actual emissions of VOC, NO_x, and CO from all stationary point and area sources (including biogenic sources), on-road mobile sources, and non-road mobile sources in an area. Required for all nonattainment areas by the 1990 Clean Air Act Amendments (CAAA). If a nonattainment area is required to perform photochemical modeling

(UAM) by the 1990 CAAA, the base year inventory must also include emissions from attainment areas located within the modeling domain.

Biogenic Emissions

Naturally occurring emissions from vegetation.

Carbon bond mechanism

The chemical kinetics mechanism employed by the Urban Airshed Model, 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 a molecular lumping approach would group reactions of entire molecules.

Crankcase evaporative emissions

Evaporative emissions emitted from motor vehicle crankcases.

Design value

A numerical value indicating the air quality for an area. For ozone, the design value is defined as the fourth highest monitored ozone value for a single monitor with three complete years of data (i.e., the greatest of the fourth-highest ozone values measured at each monitor within the area).

Diurnal evaporative emissions

Evaporative emissions from motor vehicles that occur when fuel vapor is emitted from partially filled fuel tanks of non-operating vehicles during periods of rising ambient temperatures.

Effective stack height

The sum of the actual physical stack height and the plume rise. Effective stack height 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 per throughput or activity level, used to estimate emissions for a given source.

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 codes and stack parameters.

Evaporative emissions

Emissions resulting from the volatilization of gasoline and solvents due to rising ambient temperatures, or engine heat after motor vehicle shutdown. EPA's MOBILE4.1 emission factor model recognizes five components of motor vehicle evaportive emissions: hot soak, diurnal, and crankcase, which are lumped together under "evaporative," and resting and running losses, which are reported separately.

Exhaust emissions

Emissions resulting from the combustion processes associated with the operation of motor vehicles. In EPA's MOBILE4.1 model, exhaust emissions are composed of three components, representing three different operating modes: cold start, hot start, and hot stabilized.

Grid cell

The three-dimensional box-like cell of a grid system; also commonly used to refer specifically to the groundlevel horizontal layer of grid cells over which emissions are allocated for modeling.

Grid layer

See **vertical resolution.**

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; the Urban Airshed Model (UAM) is an example of a photochemical grid model.

Growth surrogate

See **projection surrogate.**

Hot soak evaporative emissions

Evaporative emissions from motor vehicles that occur when fuel in the engine is vaporized by the residual heat of the engine after the vehicle is shut off.

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 is written as 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 or agricultural, urban, grasslands, and wetlands.

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; see also **mobile source emissions.**

Link

A surrogate generated to model allocation of line source emissions. It takes the form of a line (designated by start and endpoint coordinates), or a group of lines; spatial allocation is performed on the basis of link length per grid cell.

Lumping

In chemical mechanisms, the strategem 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

Emissions from non-stationary sources. Also commonly used to designate emissions from on-road motor vehicles only (as opposed to "other mobile" sources). 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

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

PC BEIS

A version of EPA's Biogenic Emission Inventory System, designed to run on a personal computer, which produces county-level biogenic emissions estimates.

Periodic inventory

An emission inventory based on actual emission rates and addressing both VOC and NO_x emission sources, primarily used for tracking emissions reductions, particularly relating to Reasonable Further Progress (RFP) requirements. Required for all ozone nonattainment classifications by the 1990 Clean Air Act Amendments.

Photochemical model

An air quality simulation model which simulates the photochemical reactions that occur over an area during each hour of the day or days for which the model is being applied.

Point source emissions

Emissions which are inventories as occuring 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 emisisons (due either to gas temperatures higher than the ambient air or the momentum of the emissions as they leave the stack).

PM-10

Particulate matter with particle diameters of 10 microns and smaller.

POD
A grouping of sources based on similar SCC(ASC) codes.

Projection inventory (for future year)
An inventory for a future year, derived from a base year inventory, in which emissions have been adjusted to reflect differences in activity levels and/or implemented controls between the base and future years.

Projection surrogate
A quantity for which official projections are known and whose growth may be assumed similar to that of activity for a particular source category or type.

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 network overlaid on a map of the area being modeled. Eulerian models usually assume one receptor at the center of each grid cell.

Resting losses
Evaporative emissions from nonoperating motor vehicles that result from vapors permieating parts of the evaporative emission control syste, migrating out of the carbon canister, or evaporating liquid fuel leaks. Resting losses are distinct from diurnal evaporative emissions in that they do not result from rising ambient temperatures.

RFP projection inventory
A projected inventory based on allowable rather than actual emissions and used for tracking Reasonable Further Progress (RFP) for State Implementation Plans. Required for nonattainment areas ranked moderate and above by the 1990 Clean Air Act Amendments.

Running losses
Evaporative emissions from motor vehicles that occur while the vehicle is in operation.

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

Standard Industrial Classification code
Abbreviated as SIC; a 4-digit integer code designating the primary type of business for a facility (e.g., petroleum refinery, electric utility, gasoline service station, dry cleaner, etc.).

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

Source Classification Code

Abbreviated as SCC; an 8-digit integer code used to characterize a process. For example, SCC code 40200902 corresponds to the use of acetone as a thinning solvent in surface coating operations.

Source/receptor relationship

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

Sulfur oxides

Abbreviated as SO_x; comprised primarily of sulfur dioxide (SO_2) and sulfate (SO_4).

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 spatial 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 the chemical mechanism (e.g., the carbon bond mechanism) employed in a photochemical air quality 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 air quality simulation model.

Stack parameters

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

Temporal resolution

Disaggregation of annual, seasonal, or daily emission rates into hourly rates. (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 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 emissions grid system. Mathematically, this is known as a "Lagrangian" model.

Vertical resolution

(1) Allocation of emissions to vertical layers of grid cells based on plume calculations. (2) In regard to meteorological parameters and concentrations of pollutants in ambient air, the provision (in a model) of a means of 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 B:

EPS 2.0 REPORTING CODES

TABLE B-1. Activity codes.

TABLE B-2. Control codes.

TABLE B-3. Process codes.

TABLE B-4. POD codes.

TABLE B-5. Speciation profile codes.

TABLE B-1. Activity codes.

000	UNSPECIFIED ACTIVITIES
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
211	FRUIT/VEG 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 MFG
242	DRUGS
243	CLEANING/TOILET PREP
244	PAINT MFG
245	AGRI CHEMICALS
260	PETROLEUM REFINING/RELATED
261	PETROLEUM REFINING
262	PAVING & ROOFING MATERIALS
263	PET COKE/BRIQUETTE
270	MINERAL PRODUCTS
271	GLASS/GLASS PRODUCTS
280	METALLURGICAL
281	IRON/STEEL PRODUCTION
282	IRON/STEEL FOUNDRY

TABLE B-1. Continued.

283	NONFERROUS METALS
290	MISC. MANUFACTURING
291	TEXTILES & APPAREL
292	FURNITURE & FIXTURES
293	FABRICATED METAL
294	MACHINERY
295	TRANSPORTATION EQUIPMENT
296	RUBBER & PLASTICS FAB.
297	TOBACCO MANUFACTURING
298	INSTRUMENTS
300	SERVICES & COMMERCE
310	ELECTRIC UTILITIES
320	PETROLEUM & GAS MARKETING
321	BULK PLANTS
322	SERVICE STATIONS
323	PIPE 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
450	LIGHT DUTY AUTOMOBILE
451	LDA - COLD START
452	LDA - HOT STABILIZED
453	LDA - HOT START
454	LDA - HOT SOAK
455	LDA - DIURNAL LOSSES
456	LDA - RUNNING LOSSES
460	LIGHT DUTY TRUCK
461	LDT - COLD START
462	LDT - HOT STABILIZED
463	LDT - HOT START
464	LDT - HOT SOAK
465	LDT - DIURNAL LOSSES

TABLE B-1. Concluded.

466	LDT - RUNNING LOSSES
470	MEDIUM DUTY GAS VEHICLES
471	MDGV - COLD START
472	MDGV - HOT STABILIZED
473	MDGV - HOT START
474	MDGV - HOT SOAK
475	MDGV - DIURNAL LOSSES
476	MDGV - RUNNING LOSSES
480	HEAVY DUTY GAS VEHICLES
481	HDGV - COLD TART
482	HDGV - HOT STABILIZED
483	HDGV - HOT START
484	HDGV - HOT SOAK
485	HDGV - DIURNAL LOSSES
486	HDGV - RUNNING LOSSES
500	DOMESTIC
510	RESIDENTIAL
520	RECREATIONAL
600	MISC. ACTIVITIES
610	CONSTRUCTION
611	BUILDING CONSTRUCTION
612	ROAD CONSTRUCTION
620	NATURAL SOURCES
630	GOVERNMENT
631	NATIONAL SECURITY
801	SEEPS/BIOGENIC
802	CHANNEL SHIPPING
803	OCS AND RELATED SOURCES
804	TIDELAND PLATFORMS

TABLE B-2. Control codes.

000	UNSPECIFIED
101	UTILITY BOILERS - LIQUID FUELS
102	UTILITY BOILERS - GASEOUS FUELS
103	REFINERY BOILERS & HEATERS - LIQ. 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 FURN CONTNR/SDLM
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-UTIL I.C. ENGINES - LIQUID
128	RESOURCE RECOVERY
129	BOILERS-SPACE HEATERS-LIQ 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 & PROD. - SURFACE COATING
309	METAL PARTS & PROD. - SOLVENT USE
310	PAPER - SURFACE COATING
311	PAPER - SOLVENT USE
312	FABRIC - SURFACE COATING
313	FABRIC - SOLVENT USE

TABLE B-2. Continued.

314	DEGREASING-NON-SYNTH&MISC-(IND)
315	DEGREASING-NON-SYNTH&MISC-(COMM)
316	CUTBACK ASPHALT PAVING MATERIALS
317	DRY CLEANING (NON-SYNTHETIC)
318	DRY CLEANING (SYNTHETIC&MISC)
319	GRAPHIC ARTS-EXCPT LITHO/L PTRS
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 (INDUS)
332	DEGREASING SYNTHETIC (COMM)
333	FLATWOOD PRODUCTS
334	GRAPHIC ARTS - LITHO/LTTR PRESS
398	OTHER INDUSTRIAL SURFACE COATING
399	UNSPECIFIED IND. SOLVENT USE
401	GASOLINE WORKING LOSS - BULK STORAGE
402	GASOLINE WORKING LOSS - TANK TRUCKS
403	GASOLINE WORKING LOSSES - UNDGRND TANK
404	GASOLINE WORKING LOSSES - VEHICLE TANK
405	FIXED ROOF TANKS AT REFINERIES
406	FLOATING ROOF TANKS AT REFINERIES
407	MARINE VESSEL OPERATION - EVAP.
410	OIL PRODUCTION FIELDS STORAGE TANKS
411	MARINE LIGHTERING
412	GASOLINE BREATHING LOSS - UNDG
413	GASOLINE BREATHING LOSS - ABOVEG
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 PROD.-VALVES,FLANGES,CONNECTORS
507	SMALL RELIEF VALVES
508	NON-REFINERY VALVES
510	VEGETABLE OIL PROCESSING
511	PAINT MANUFACTURING
512	RUBBER PRODUCTS FABRICATION

TABLE B-2. Continued.

513	CHEMICAL MANUFACTURING
514	PHARMACEUTICAL MANUFACTURING
515	RUBBER PRODUCTS MANUFACTURING
518	OIL PROD. 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 PROD. PUMP AND COMPRESSORS
531	OIL PROD. HEAVY OIL TEST STATION
532	OIL PROD. CYCLIC WELL VENTS
533	OIL PROD. 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 (NON-SYNTHETIC)
606	AEROSOL PROPELLANT SYNTHETIC
607	AEROSOL PROPELLANT NON-SYNTHETIC
608	WASTE DISPOSAL LANDFILL
609	DOMESTIC SOLVENT USE
610	AEROSOL CONSUM PROD PROPELLANT
611	AEROSOL CONSUM PROD SOLVENT
612	NON-AEROSOL CONSUM PROD SOLVNT
620	AGRICULTURAL PESTIC - SYNTHETIC
621	AGRICULTURAL PESTIC - NON-SYNTH
622	OTHER PESTIC - SYNTHETIC
623	OTHER PESTIC - NON-SYNTH
651	UNPAVED CITY/COUNTY ROAD DUST
711	LDGV - EXHAUST
712	LDA - HOT START
713	LDA - HOT STABILIZED
714	LDGV - EVAPORATIVE
715	LDGV - RUNNING LOSSES
716	LDA - CRANKCASE BLOWBY
717	LDA - TIRE WEAR
718	LDGV - REFUELING

TABLE B-2. Continued.

719	GASV - OFF-HIGHWAY EXHAUST
720	GASV - OFF-HIGHWAY EVAPORATIVE
721	LDT - COLD START
722	LDT - HOT START
723	LDT - HOT STABILIZED
724	LDT - HOT SOAK EVAP.
725	LDT - DIURNAL EVAP.
726	LDT - CRANKCASE BLOWBY
727	LDT - TIRE WEAR
731	MDGV - EXHAUST
732	MDT - HOT START
733	MDT - HOT STABILIZED
734	MDGV - EVAPORATIVE
735	MDGV - RUNNING LOSSES
736	MDT - CRANKCASE BLOWBY
737	MDT - TIRE WEAR
738	MDGV - REFUELING
741	HDGV - EXHAUST
742	HDG - HOT START
743	HDG - HOT STABILIZED
744	HDGV - EVAPORATIVE
745	HDGV - RUNNING LOSSES
746	HDG - CRANKCASE BLOWBY
747	HDG - TIRE WEAR
748	HDGV - REFUELING
751	HDD - EXHAUST
753	HDD - HOT STABILIZED
757	HDD - TIRE WEAR
759	HDD - OFF-HIGHWAY EXHAUST
761	MCY - COLD START
762	MCY - HOT START
763	MCY - HOT STABILIZED
764	MCY - HOT SOAK EVAP.
765	MCY - DIURNAL EVAP.
766	MCY - CRANKCASE BLOWBY
767	MCY - TIRE WEAR
801	NON-FARM EQUIPMENT (GASOLINE)
802	FARM EQUIPMENT (DIESEL)
803	LAWN & GARDEN EQUIP (UTILITY)
804	OFF-ROAD MOTORCYCLES
805	PLEASURE CRAFT (BOATS)

TABLE B-2. Continued.

806	RAILROAD LINE HAUL OPERATIONS
807	COMM./CIVIL PISTON AIRCRAFT
808	COMM. 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
826	LDA - CAT - RUNNING LOSSES
827	LDA - CAT - TIREWEAR
831	LDA - DSL - COLD START
832	LDA - DSL - HOT START
833	LDA - DSL - HOT STABILIZED
837	LDA - DSL - TIREWEAR
841	LDT - NCAT - COLD START
842	LDT - NCAT - HOT START
843	LDT - NCAT - HOT STABILIZED
844	LDT - NCAT - HOT SOAK
845	LDT - NCAT - DIURNAL
846	LDT - NCAT - RUNNING LOSSES
847	LDT - 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
856	LMDT - CAT - RUNNING LOSSES
857	LMDT - CAT - TIREWEAR
861	LMDT - DSL - COLD START
862	LMDT - DSL - HOT START
863	LMDT - DSL - HOT STABILIZED
867	LMDT - DSL - TIREWEAR
873	HDT - NCAT - HOT STABILIZED

TABLE B-2. Concluded.

874	HDT - NCAT - HOT SOAK
875	HDT - NCAT - DIURNAL
876	HDT - NCAT - CRANKCASE
877	HDT - NCAT - TIREWEAR
881	HDT - CAT - COLD START
882	HDT - CAT - HOT START
883	HDT - CAT - HOT STABILIZED
884	HDT - CAT - HOT SOAK
885	HDT - CAT - DIURNAL
886	HDT - CAT - RUNNING LOSSES
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

TABLE B-3. Process codes.

000	UNSPECIFIED PROCESSES
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 - CMBSTN GASES
140	EQUIPMENT
141	UTILITY EQUIPMENT
142	MOBILE EQUIPMENT
200	WASTE BURNING
210	INCINERATION
211	CONICAL BURNER
220	OPEN BURNING
221	AGRI 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
560	WOOD & PAPER PROCESSES

TABLE B-3. Concluded.

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
730	TRAINS
740	SHIPS
750	AIRCRAFT
801	SEEPS/BIOGENIC
802	CHANNEL SHIPPING
803	OCS AND RELATED SOURCES
804	TIDELAND PLATFORMS

TABLE B-4. POD codes.

0	Combustion point and area sources
1	Solvent metal cleaning
2	Printing/publishing
3	Dry cleaning
4	Fixed roof tanks - crude
5	Fixed roof tanks - gasoline
6	EFR tanks - crude
7	EFR tanks - gasoline
8	Bulk terminals - splash fill
9	Bulk terminals - subm. bal.
10	Bulk terminals - not bal.
11	Stage I refueling controls
15	Ethylene oxide manufacturing
16	Phenol manufacturing
17	Terephthalic acid manufacturing
18	Acrylonitrile manufacturing
19	SOCMI fugitives
20	Refinery fugitives
21	Cellulose acetate manufacturing
22	Styrene butadiene manufacturing
23	Propylene manufacturing
24	Polyethylene manufacturing
25	Ethylene manufacturing
26	Refinery wastewater treatment
27	Refinery vacuum distillation
28	Vegetable oil processing
29	Paint and varnish manufacture
30	Rubber tire manufacturing
31	Green tire spray
32	Carbon black
33	Automobile coating
34	Can coating
35	General surface coating
36	Paper coating
37	Miscellaneous surface coating
301	Surface coating - coils
302	Surface coating - large appliances
303	Surface coating - fabrics
304	Surface coating - magnet wire
305	Surface coating - misc. metal parts
38	Food/agricultural starch mfg.

TABLE B-4. Continued.

39	Coke byproduct plants
43	Marine vessel loading
46	Charcoal manufacturing
47	Whiskey production
48	Plastic parts coating
49	Wood furniture coating
50	Utility - pulv coal
661	Utility - coal stokers
51	Utility boilers - oil
52	Utility boilers - gas
53	Utility boilers - other
54	Industrial inprocess fuel combustion
55	Industrial process heaters
56	Industrial ext comb - space heaters
57	Industrial ext comb - other
58	Comm/inst - pulv coal
663	Comm/inst - coal stokers
59	Comm/inst - oil
60	Comm/inst - gas
61	Comm/inst ext comb - other
63	Internal combustion - other
64	Solid waste disposal
70	Indl oil turbine
71	Indl oil recip
72	Indl gas turbine
73	Indl gas recip
74	Utility oil turbine
75	Utility oil recip
76	Utility gas tubine
77	Utility gas recip
78	Indl IC - dist oil turbine, cogen
79	Indl IC - dist oil engine, cogen
80	Indl IC - nat gas turbine, cogen
81	Indl IC - nat gas engine, cogen
83	Indl ext comb - coal, cogen
84	Indl coal boilers
85	Indl boilers - resid oil
86	Indl boilers - resid oil
87	Indl boilers - resid oil
662	Indl boilers - dist oil
88	Indl boilers - nat gas

TABLE B-4. Concluded.

89	Indl boilers - nat gas
90	Indl boilers - nat gas
95	Aircraft coating
96	SOCMI reactors
97	SOCMI distillation
99	Unspecified
1040	Paper coating
1041	Degreasing
1042	Dry cleaning
1043	Printing
1044	Rubber and Plastics manufacture
1045	Misc. surface coating
1046	Automobile Refinishing
1047	Architectural surface coating
1048	Misc. industrial solvents
1049	Consumer solvents
1060	Light Duty Gasoline Vehicles
1061	Light Duty Gasoline Trucks
1062	Heavy Duty Gasoline Vehicles
1063	Heavy Duty Diesel Vehicles
1064	Off highway vehicles
1065	Railroads
1066	Open burning, forest fires, prescribed burns
1067	Area source incineration
1068	Aircraft and Marine Vessels
1070	Treatment, storage and disposal facilities
1071	Bakeries
1072	Cutback Asphalt
1073	Public Treatment works
1074	SOCMI fugitives
1075	Gasoline bulk terminals and plants
1076	Petroleum refinery fugitives
1077	Pharmaceutical manufacture
1078	Synthetic fiber manufacture
1079	Oil and natural gas production fields
1080	Service stations - Stage I - truck unloading
1081	Service stations - Stage II - vehicle refueling
1082	Gasoline refueling - spillage
1083	Gas serv. station underground tank breathing loss

TABLE B-5. Speciation profile codes.

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 Fug. Ems. - Covered Drainage/Sep. Pits
0035	Refinery Fugitive Emissions - Cooling Towers
0039	Refinery Fug. Ems. - Compressor Seals Refinery Gas
0047	Refinery Fug. Ems. - Relief Valves, L.P.G.
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
0166	Printing Press - Letterpress Inking Process
0182	Printing Press - Gravure General Solvent

TABLE B-5. Continued.

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
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

TABLE B-5. Continued.

1002	Chemical Menufacturing - Carbon Black Production
1003	Surface Coating Application - Solvent-base Paint
1004	Plastics Production - Polystyrene
1005	Plastics Production - Polyester Resins
1006	Phthalic Anhyd. - o-Xyl. Oxidation- Process Stream
1007	Mineral Products - Asphaltic Concrete
1008	Rubber and Misc. Plastics Prod.- Styrene/Butadiene
1009	Plastics Prod.-Acrylontrl.-Butadiene-Styerne Resin
1010	Oil & Gas Production - Fugitives - Unclassified
1011	Oil & Gas Prod. - Fug. - Valves & Fit. -Liq. Serv.
1012	Oil & Gas Prod. - Fug. - Valves & Fit. -Gas Serv.
1013	Surface Coating Application - Water-base Paint
1014	Gasoline - Summer Blend
1015	Gasoline - Winter Blend
1016	Surface Coating -Thinning Solvents - Composite
1017	Surface Coating Application - Lacquer
1018	Surface Coating Application - Enamel
1019	Surface Coating Application - Primer
1020	Surface Coating Application - Adhesives
1021	Degreasing - Open Top - Chlorosolve
1022	Print./Publishing-Thin. Solv.-Met. Isobutyl Ketone
1023	Terepht.Acid/Dimet.Terepht.-Crys., Sep.,Drying Vat
1024	Terepht. Acid/Dimet.Terepht. - Distil. & Rec. Vent
1025	Terepht. Acid/Dimet.Terepht. - Prod. Transfer Vent
1026	Surface Coating - Thinning Solv. - Hexylene Glycol
1027	Ketone Production - Methyl Ethyl Ketone (MEK)
1028	Acetone - Light Ends Distillation Vent
1029	Acetone - Acetone Finishing Column
1030	Aldehydes Prod. - Formaldehyde - Absorber Vent
1031	Surface Coating - Thinning Solv. - Ethylene Oxide
1032	Aldehydes Prod. - Acrolein - Distillation System
1033	Aldehydes Prod. - Acrolein - Reactor Blowoff Gas
1034	Chloroprene -Butadiene Dryer
1035	Chloroprene - Clprene Stripper & Brine Stripper
1036	Secondary Aluminum - Pouring and Casting
1037	Organohlgns.-Ethylene DiCl-Dir. Chlorin.-Dist. Ven
1038	Organohlgns. Prod.-Ethylene DiCl-Oxychlorination
1039	Organohlgns. Prod.-Ethylene DiCl-Caustic Scrubber
1040	Flourocarbons/Chlorofluorocarbons - General
1041	Flourocarbons/Chlorofluorocarbons - Dist. Column
1042	Flourocarbons/Chlorofluorocarbons- Fug. Ems.- Gen.

TABLE B-5. Continued.

1043	Acrylic Acid - Quench Absorber
1044	Organic Acids Production - Formic Acid
1045	Organic Acids Prod.-Acetic Anhyd.-Dist. Column Ven
1046	Esters Production - Acrylates - Ethyl Acrylate
1047	Esters Production - Butyl Acrylate
1048	Cumene Prod. - Cumene Distillation System Vent.
1049	Cyclohexane - General
1050	Cyclohxnone/Cyclohxnol- Phenol Hydrogen.- Dist.Ven
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- O2 Oxidation Proc.-CO2 Purge Vent
1057	Ethylene Oxide- O2 Oxidation Proc.-Argon Purge Ven
1058	Ethylene Oxide - Stripper Purge Vent
1059	Met. Methacrylate - Hydrolysis, Light Ends, Dist.
1060	Met. Methacrylate (MMA) - Acid Dist. & MMA Purif.
1061	Nitrobenz. -Reactor & Sep. Vent- Wash. & Ntrl. Ven
1062	Benzene
1064	Olefins Prod. - Ethylene - Compressor Lube Oil Ven
1065	Propylene Oxide - Chlorohydronation Process - Gen.
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
1072	Chlorobenzene - Tail Gas Scrubber
1073	Chlorobenzene - Benzene Drying Distillation
1074	Monochlorobenzene
1075	Chlorobenzene - Vacuum System Vent
1076	Chlorobenzene - Dichlorobenzene Crystallization
1077	Clbenzene - DiClbenzene Crystal Handling/Loading
1078	Railcar Clean.- Low Pres,High Visc (Ethyl. Glycol)
1079	Railcar Clean.- Low Pres,Med Visc (o-DiClbenz.)
1080	Railcar Clean.- Low Pres,High Visc (Cresote)
1081	Tank Truck Clean.- Med Pres,Med Visc (MMA)
1082	Tank Truck Clean.- Low Pres,Low Visc (Phenol)
1083	Tank Truck Clean.-Low Pres,High Visc(Propyl. Glyc.
1084	Residential Wood Combustion (C1-C6)

TABLE B-5. Continued.

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	Sec. Metal Prod. -Gray Iron Fndr. -Pouring/Casting
1090	Fluorocarbon Manufacturing - CF 12/11
1091	Plastics Prod. - Polyvinyl Chlorides & Copolymers
1092	Synthetic Organic Fiber Prod. - Nylon Batch Prod.
1093	Fluorocarbon Manufacturing - CF 23/22
1094	Paint Manufacture - Blending Kettle
1095	Textile Prod. - Gen. Fabric Oper. -Dyeing & Curing
1096	Textile Prod. - Gen. Fabric Oper. - 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
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

TABLE B-5. Continued.

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
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

TABLE B-5. Continued.

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
1202	Primary Aluminum Production
1203	Light-Duty Gasoline Vehicles - Exhaust Emissions
1204	Light-Duty Gasoline Vehicles - Evaporative Ems.
5001	Light-Duty Automobiles - Cold Start Emissions
5002	Light-Duty Automobiles - Hot Stabilized Emissions
5003	Light-Duty Automobiles - Hot Start Emissions
5004	Light-Duty Automobiles - Hot Soak Emissions
5005	Light-Duty Automobiles - Diurnal Losses
5006	Light-Duty Automobiles - Running Losses
5011	Light-Duty Truck - Cold Start Emissions
5012	Light-Duty Truck - Hot Stabilized Emissions
5013	Light-Duty Truck - Hot Start Emissions
5014	Light-Duty Truck - Hot Soak Emissions
5015	Light-Duty Truck - Diurnal Losses
5016	Light-Duty Truck - Running Losses
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

TABLE B-5. Concluded.

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 Prod. - 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 & Marketing of Petroleum Prod. -Avg
9028	Organic Chemical Storage - Average
9029	Org Chem Strg - Fixed Roof Tank - Alcohols -Avg
9030	Org Chem Strg - Fixed Roof Tank - Alkanes -Average
9031	Org Chem Strg - Fixed Roof Tank - Alkenes -Average
9032	Org Chem Strg - Fixed Roof Tank - Amines - Average
9033	Org Chem Strg - Fixed Roof Tank - Aromatics - Avg
9034	Org Chem Strg - Fixed Roof Tank - Carb. Acids -Avg
9035	Org Chem Strg - Fixed Roof Tank - Esters - Average
9036	Org Chem Strg -Fixed Roof Tank -Glycol Ethers -Avg
9037	Org Chem Strg - Fixed Roof Tank - Glycols - Avg
9038	Org Chem Strg - Fixed Rf Tk -Halogenated Org - Avg
9039	Org Chem Strg - Fixed Roof Tank - Isocyanates -Avg
9040	Org Chem Strg - Fixed Roof Tank - Ketones - Avg
9041	Org Chem Strg - Float. Roof Tank - Aldehydes - Avg
9042	Org Chem Strg - Float. Roof Tank - Alkanes - Avg
9043	Org Chem Strg - Float. Roof Tank - Ethers - Avg
9044	Org Chem Strg - Float. Rf Tk -Halogenated Org- Avg
9046	Org Chem Strg - Pres Tanks - Alkenes - Average
9047	Org Solvent Evaporation - Miscellaneous - Average

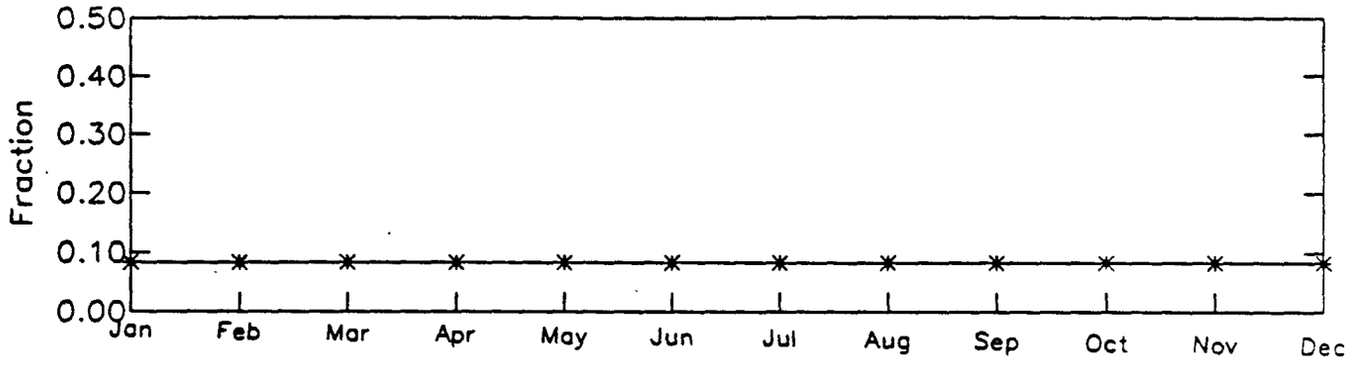
APPENDIX C:

EPS 2.0 TEMPORAL PROFILES

TEMPORAL PROFILE
/MONTHLY/

EPS Temporal Profiles

Profile #: 1 Maximum: 0.08



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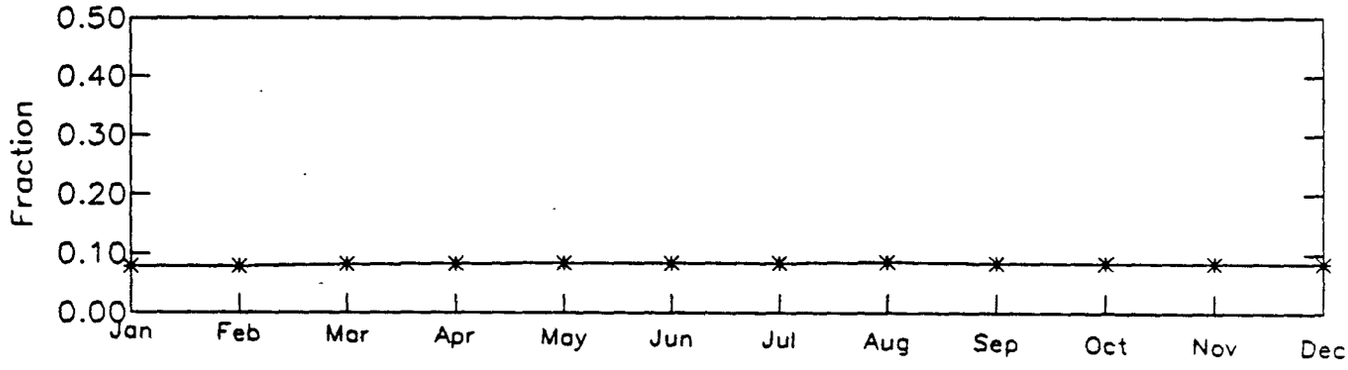

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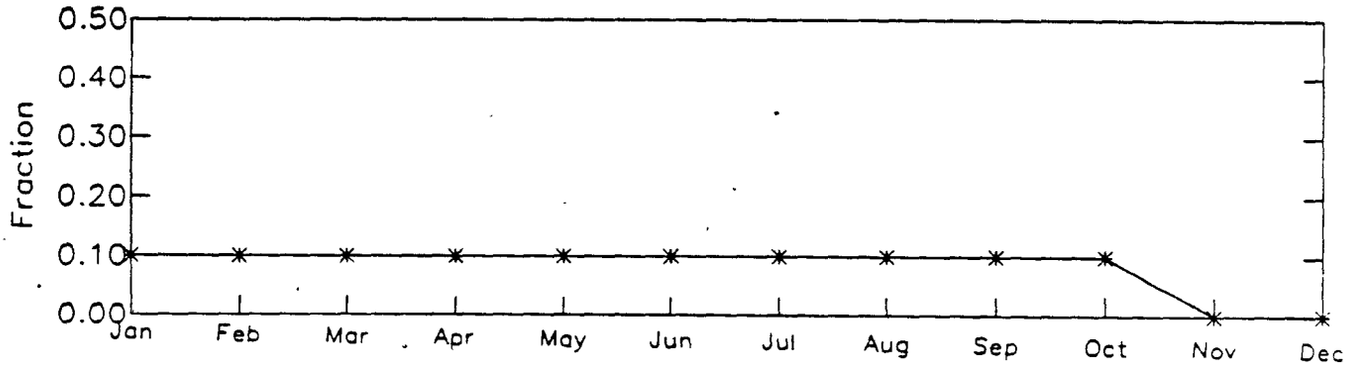

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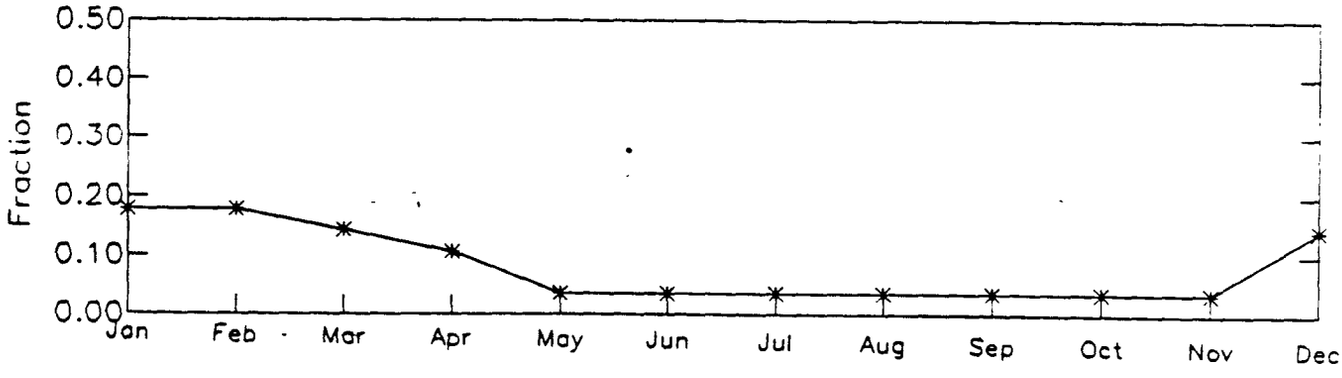

TEMPORAL PROFILE
/MONTHLY/

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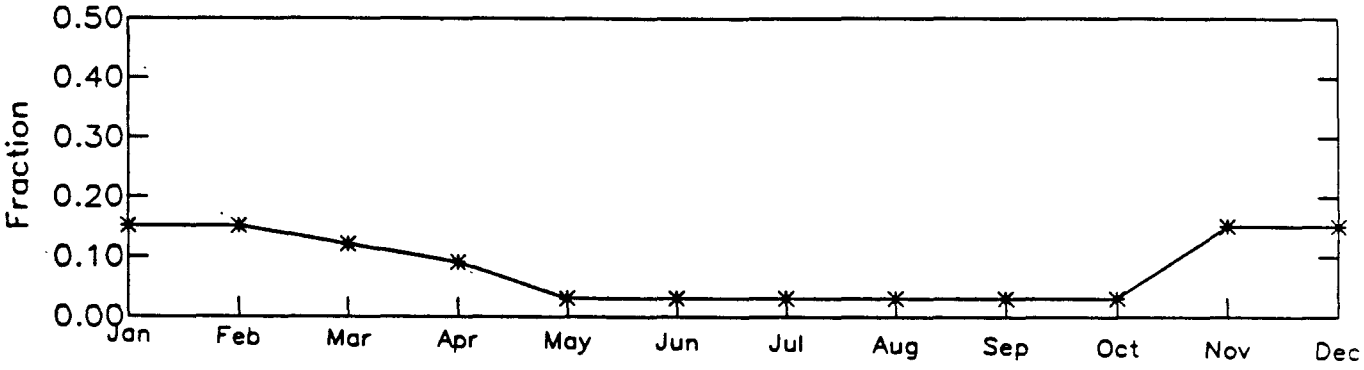

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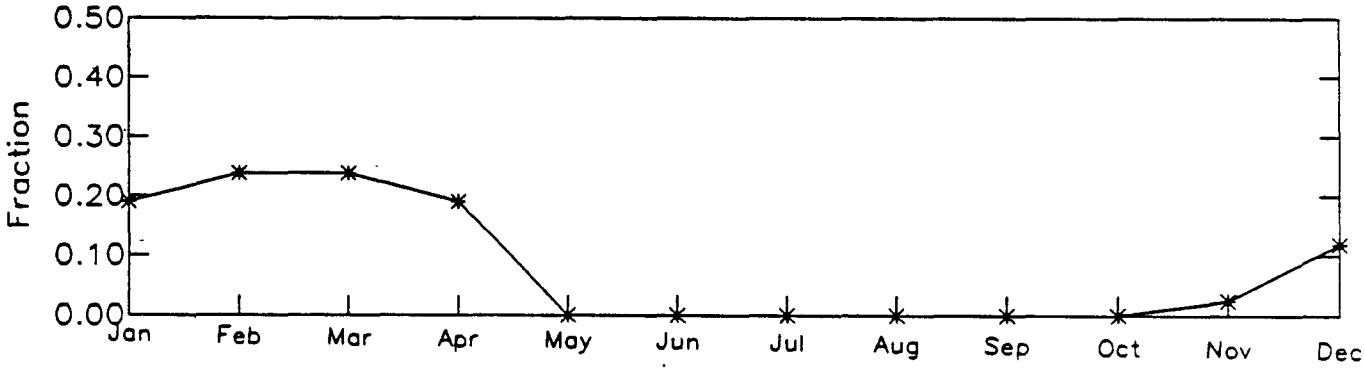
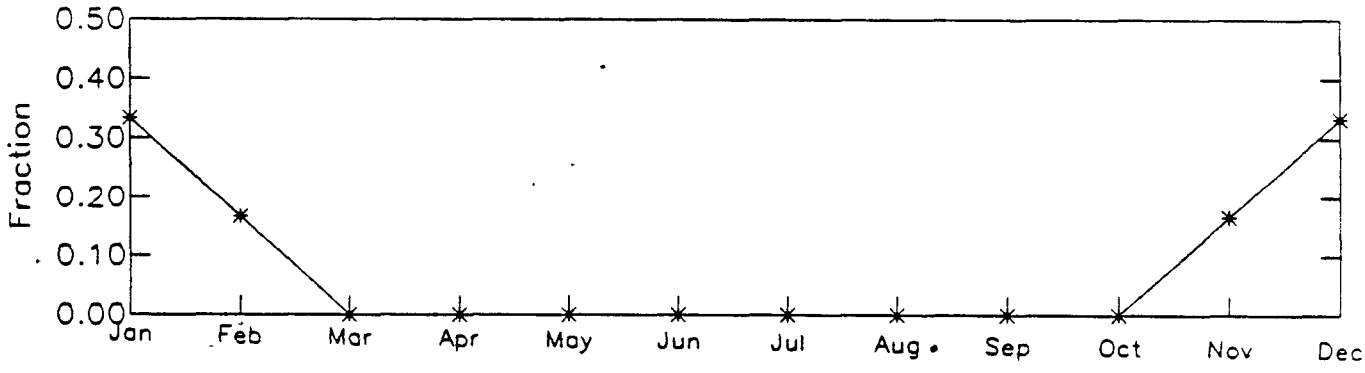
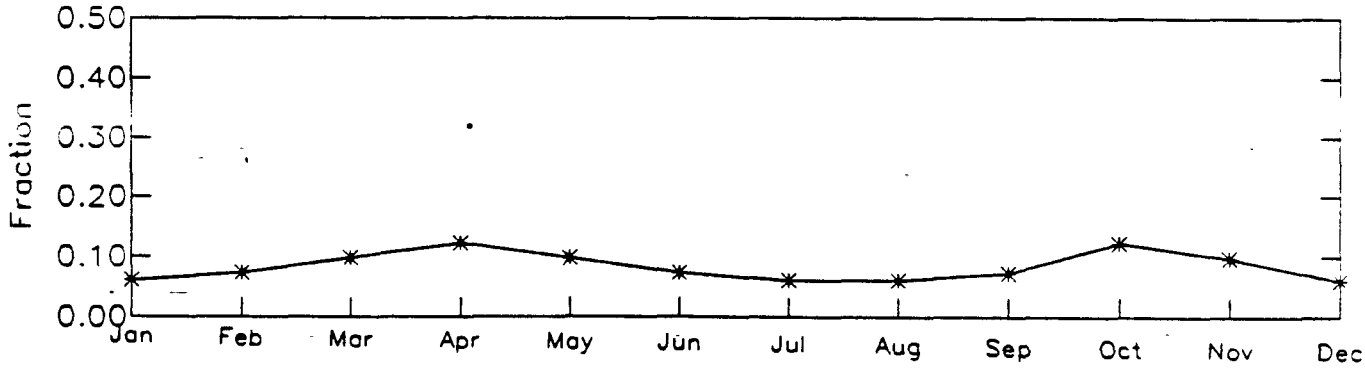


Profile #: 7 Maximum: 0.33



Profile #: 8 Maximum: 0.12

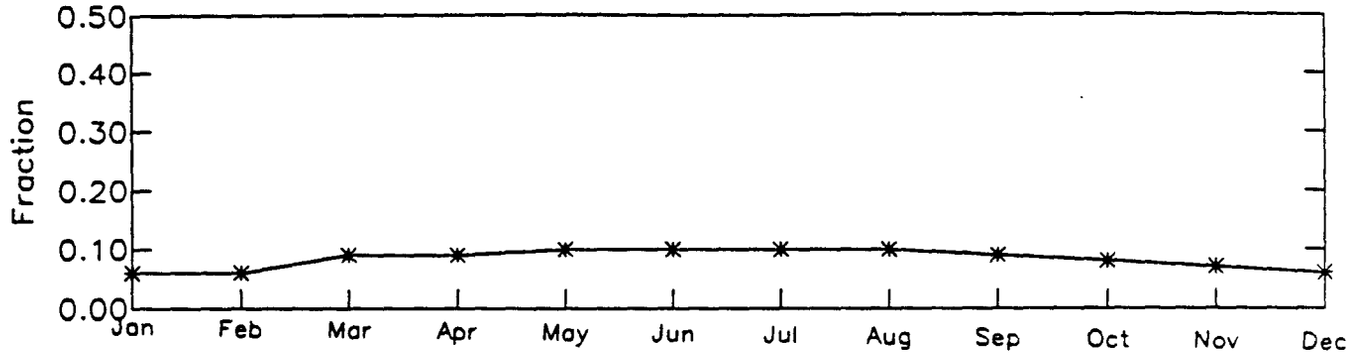


PROFILE: Wed Oct 7 22:09:39 1992

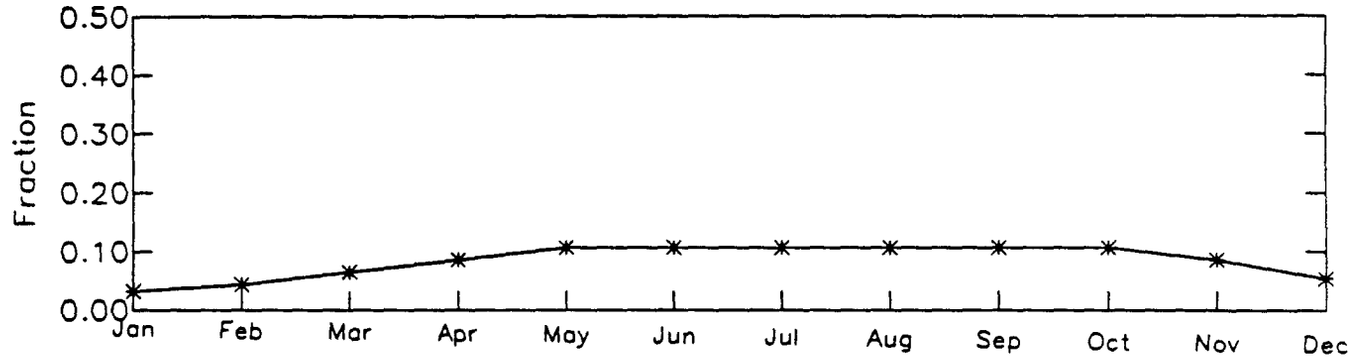
TEMPORAL PROFILE
/MONTHLY/

EPS Temporal Profiles

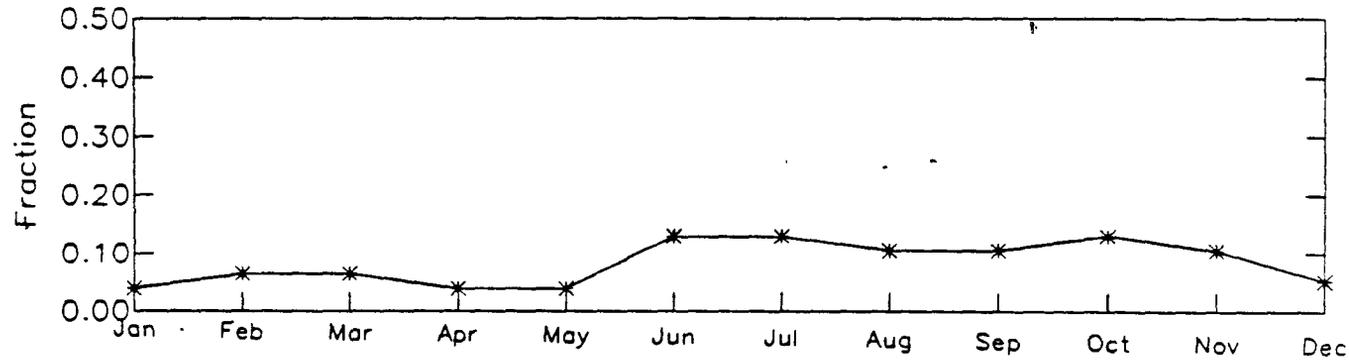
Profile #: 9 Maximum: 0.10



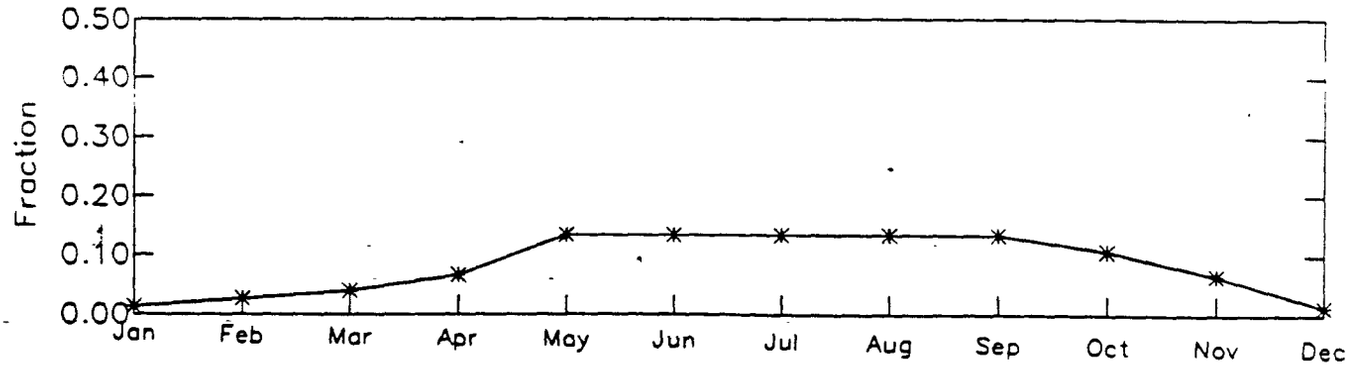
Profile #: 10 Maximum: 0.11



Profile #: 11 Maximum: 0.13



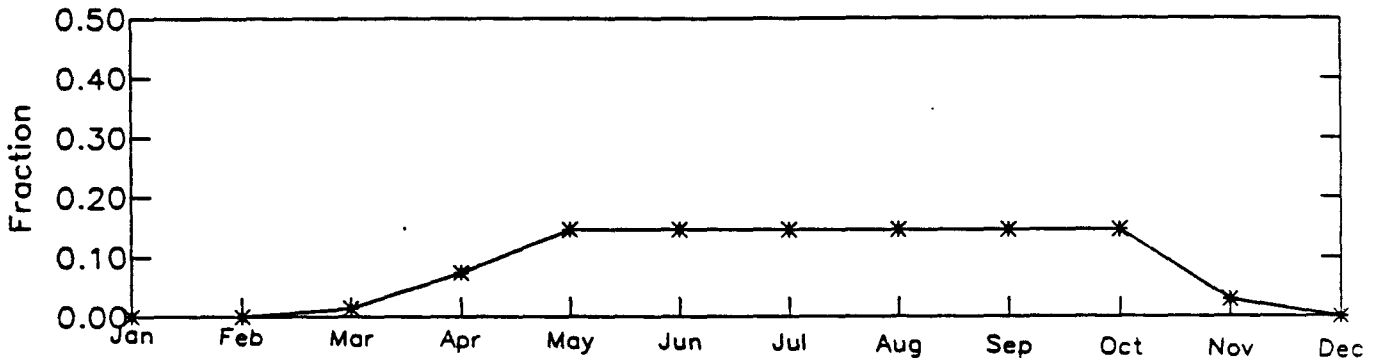
Profile #: 12 Maximum: 0.13



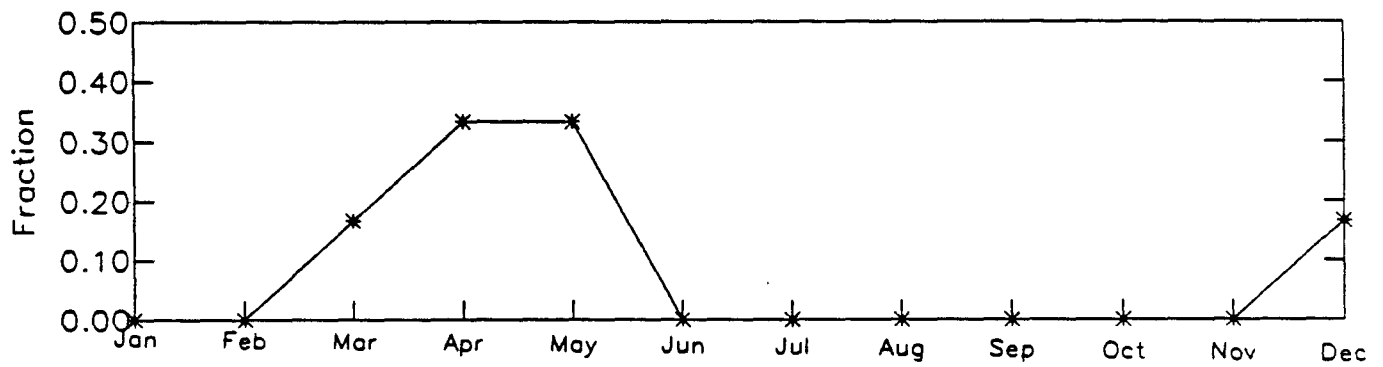
Profile: Wed Oct 7 22:09:39 1992

TEMPORAL PROFILE
/MONTHLY/

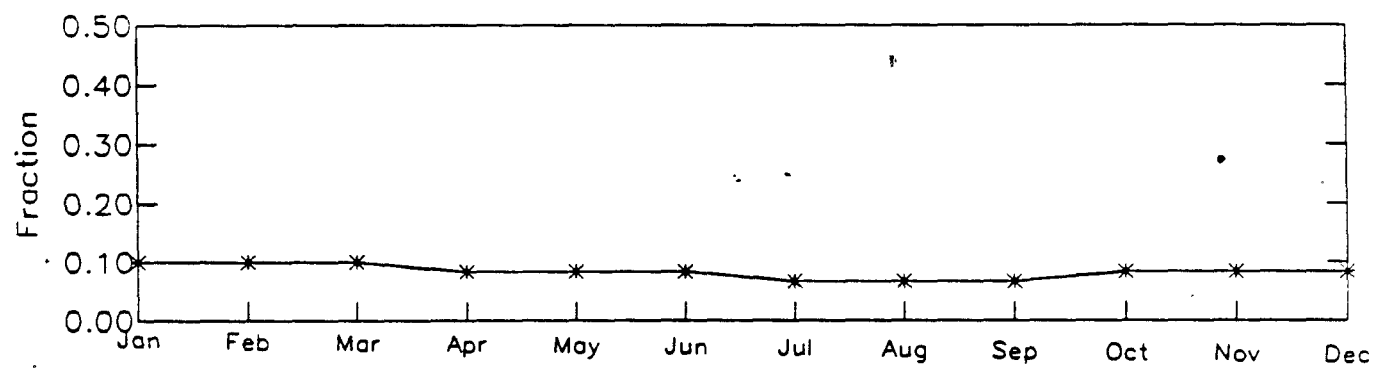
Profile #: 13 Maximum: 0.15



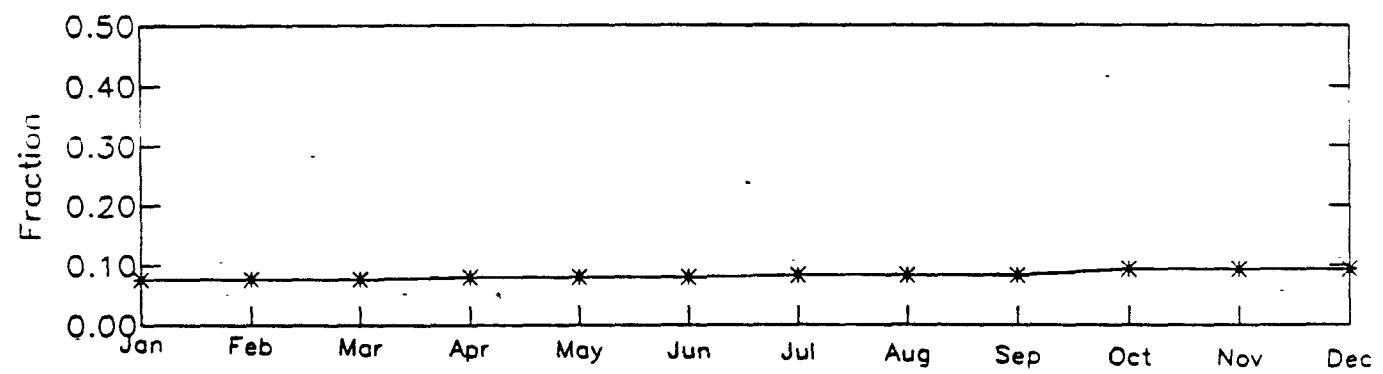
Profile #: 14 Maximum: 0.33



Profile #: 16 Maximum: 0.10



Profile #: 17 Maximum: 0.09



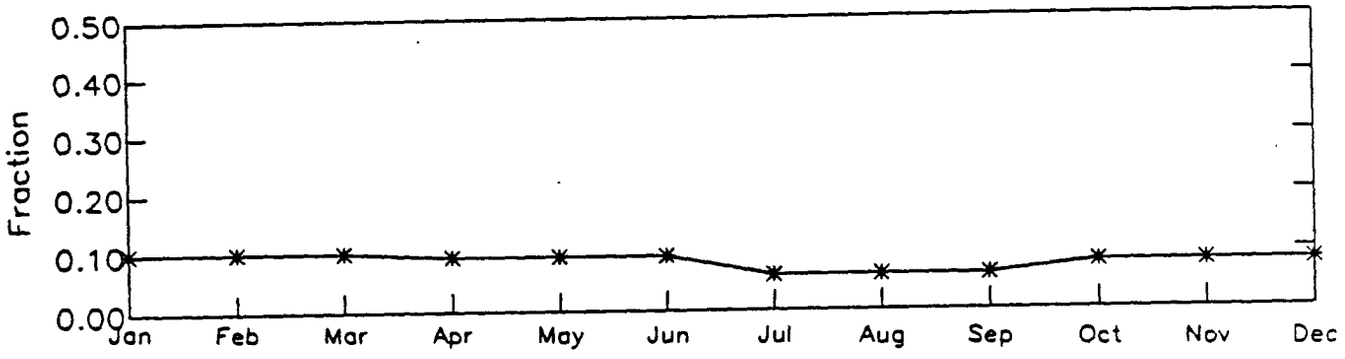
PROFILE: Wed Oct 7 22:09:39 1992

TEMPORAL PROFILE
/MONTHLY/

EPS Temporal Profiles

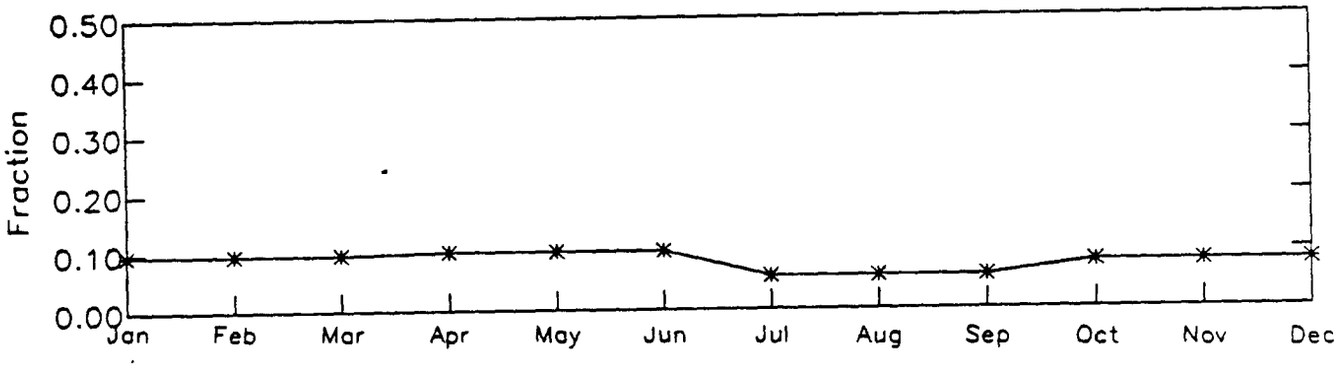
Profile #: 18

Maximum: 0.10



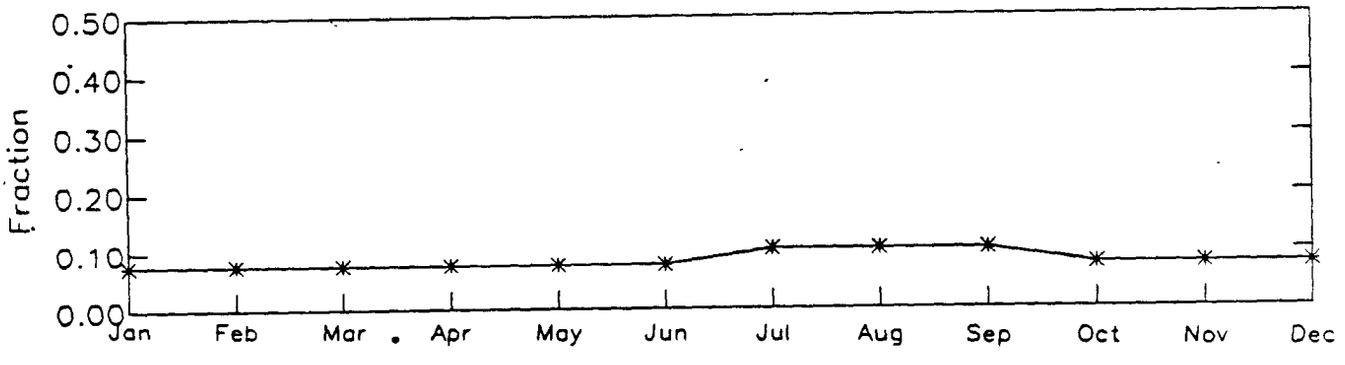
Profile #: 19

Maximum: 0.10



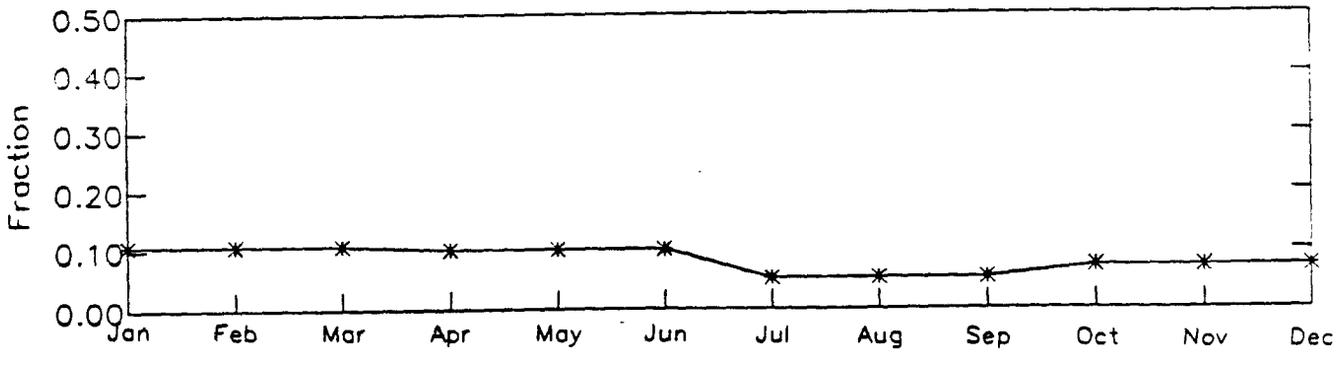
Profile #: 20

Maximum: 0.10



Profile #: 21

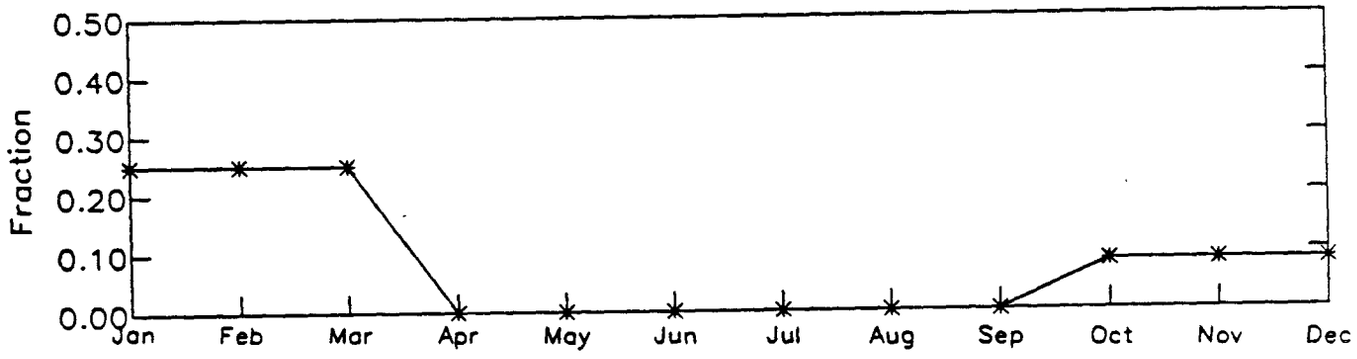
Maximum: 0.11



TEMPORAL PROFILE
/MONTHLY/

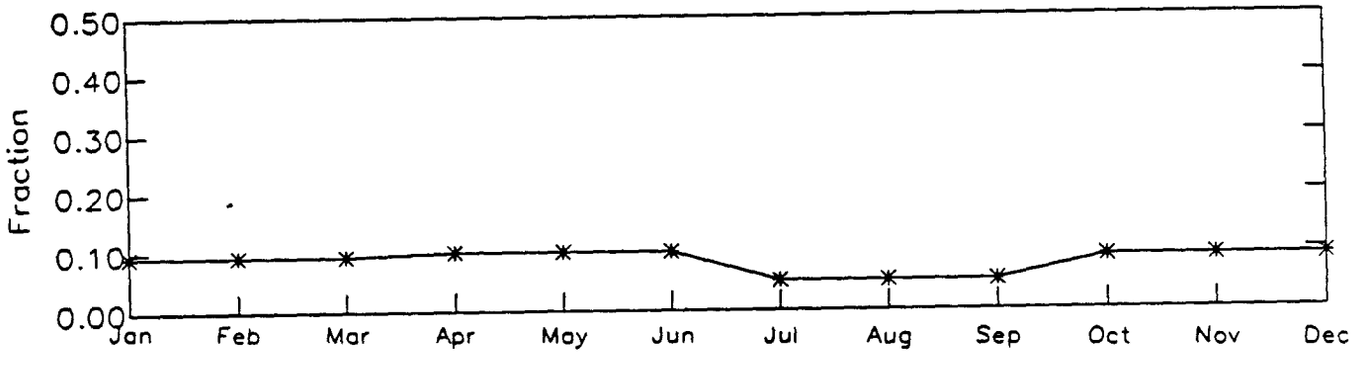
Profile #: 22

Maximum: 0.25



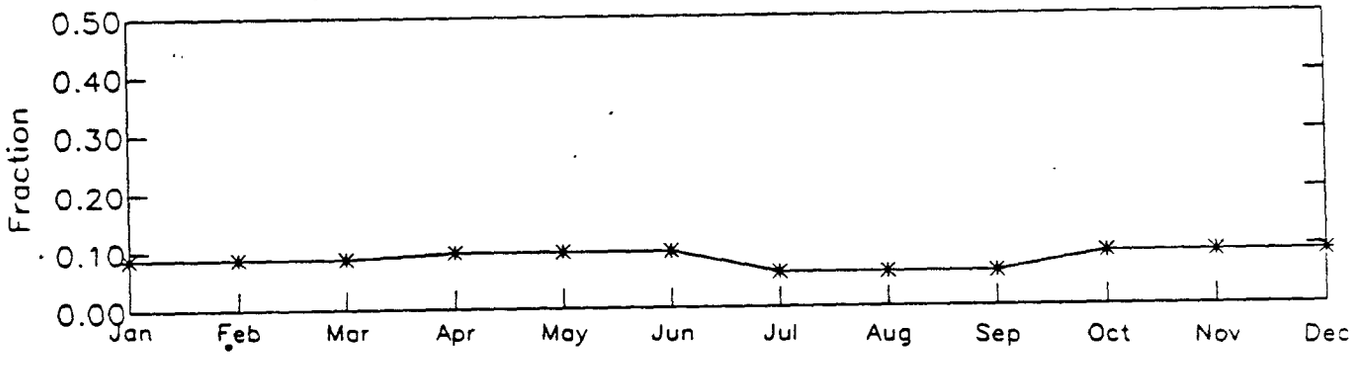
Profile #: 23

Maximum: 0.10



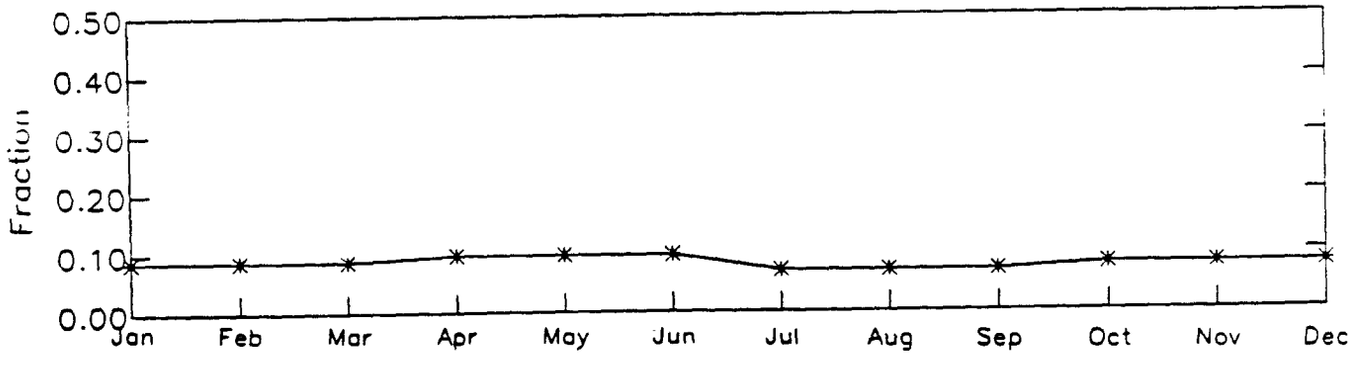
Profile #: 24

Maximum: 0.10



Profile #: 25

Maximum: 0.10

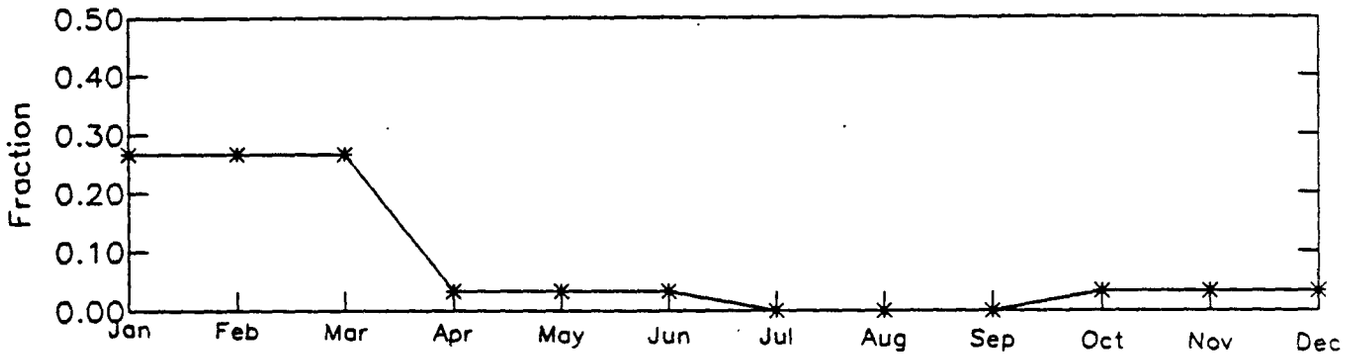


PROFILE: Wed Oct 7 22:09:40 1992

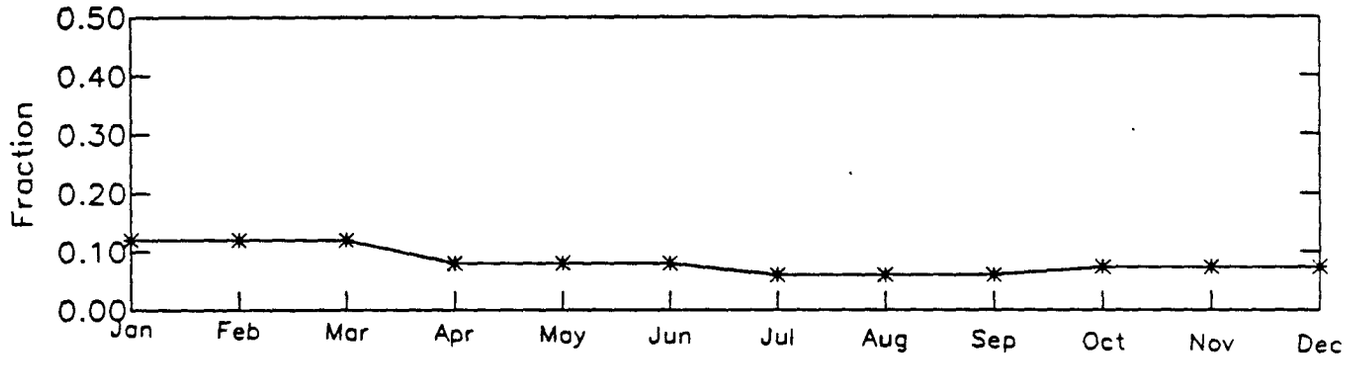
TEMPORAL PROFILE
/MONTHLY/

EPS Temporal Profiles

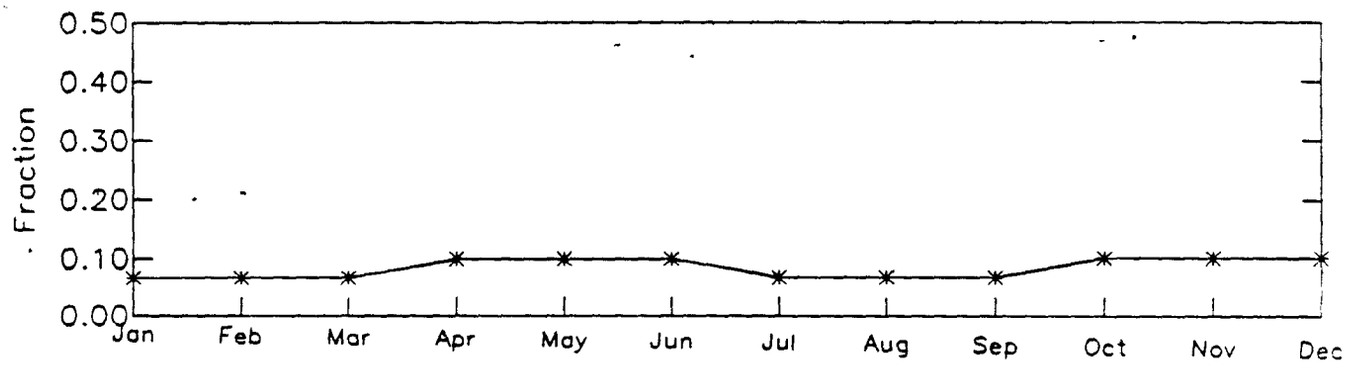
Profile #: 26 Maximum: 0.27



Profile #: 27 Maximum: 0.12



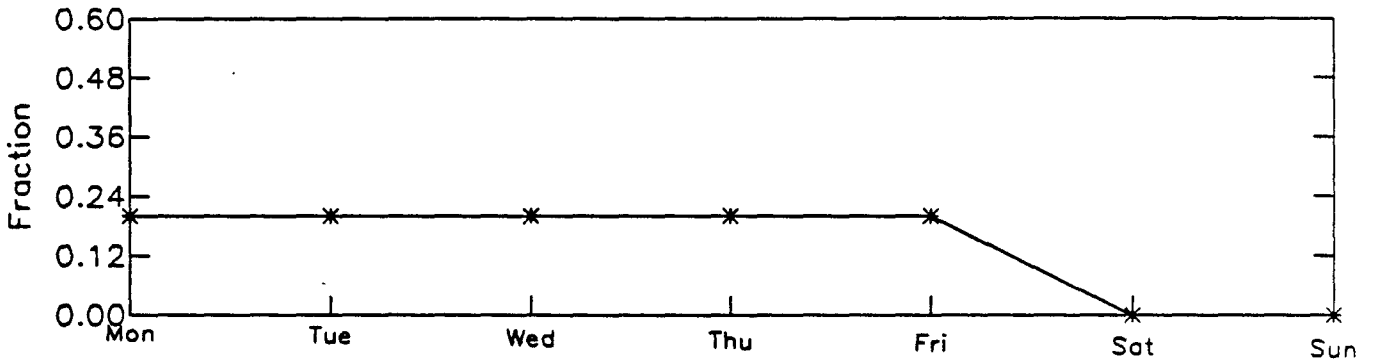
Profile #: 28 Maximum: 0.10



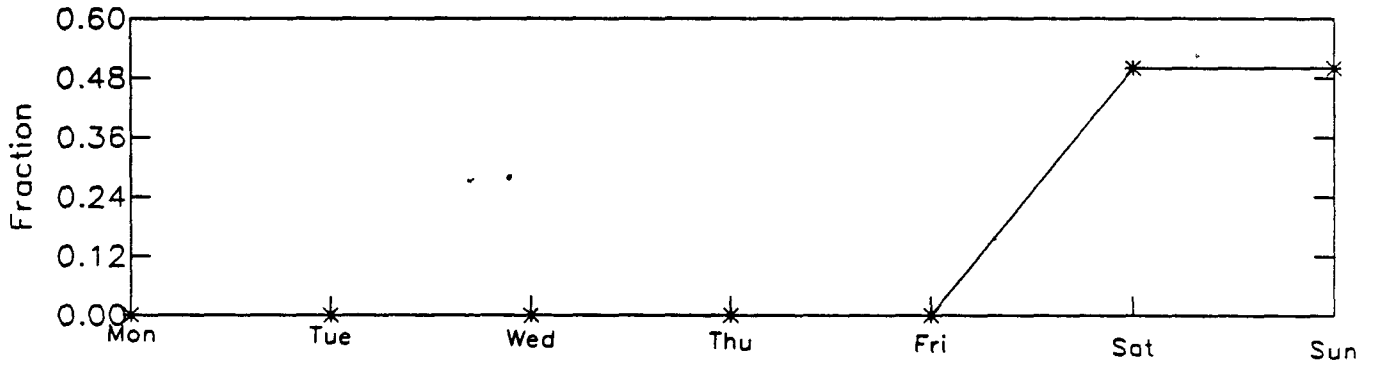
TEMPORAL PROFILE
/WEEKLY/

EPS Temporal Profiles

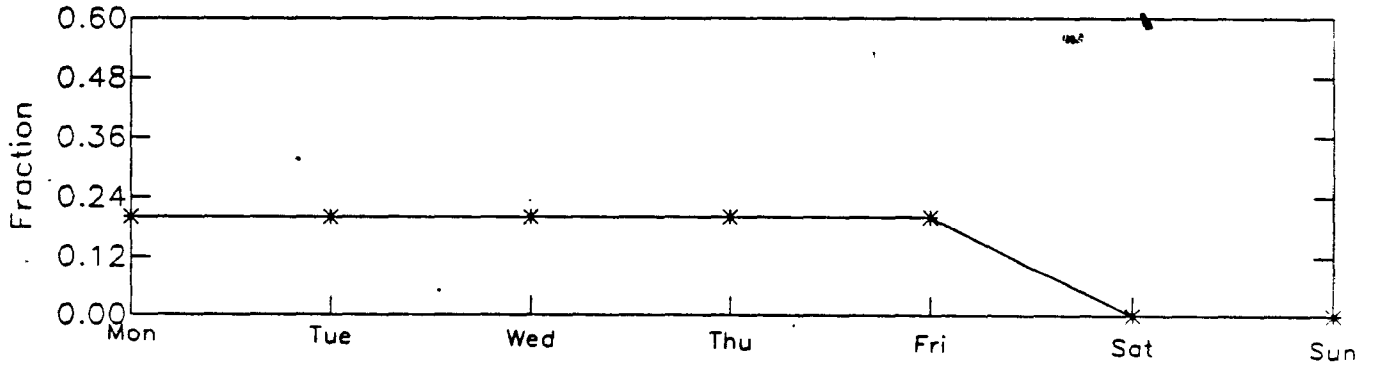
Profile #: 1 Maximum: 0.20



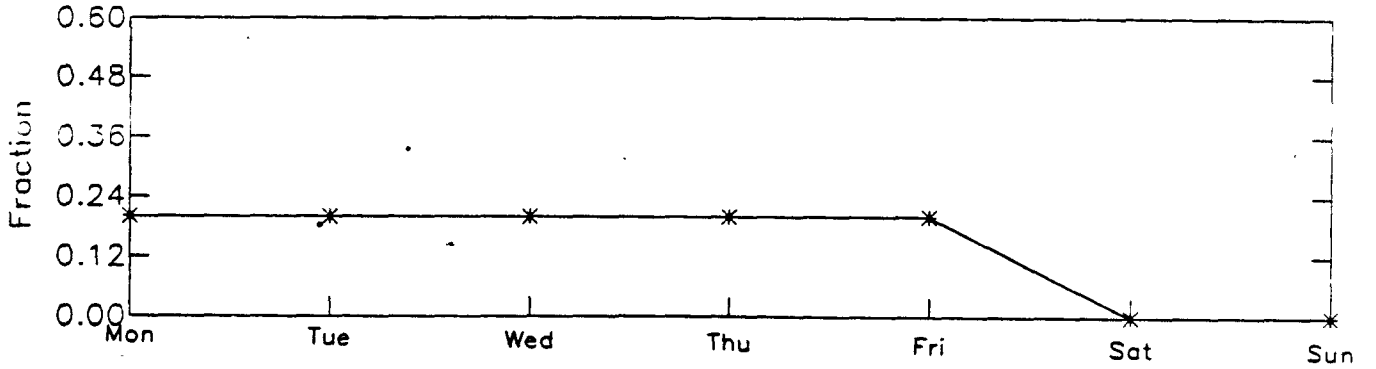
Profile #: 2 Maximum: 0.50



Profile #: 3 Maximum: 0.20



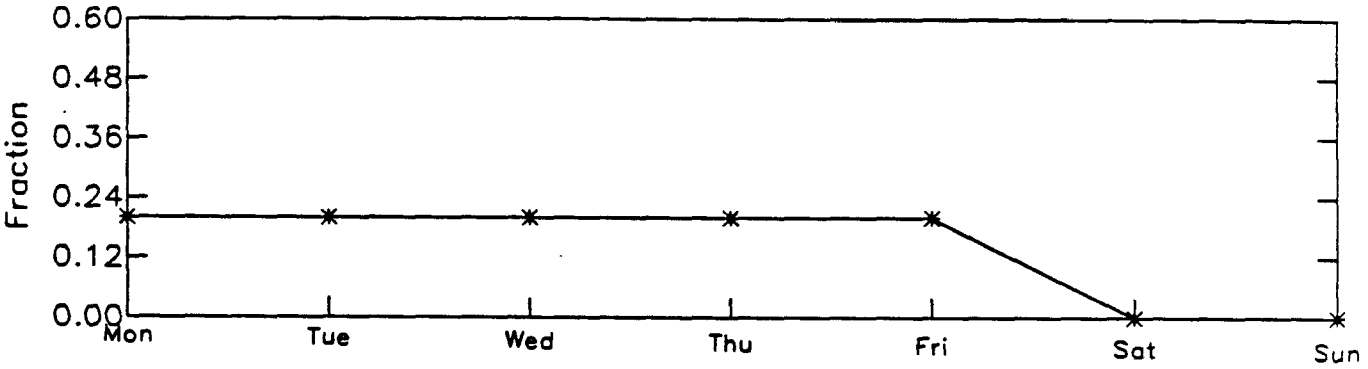
Profile #: 4 Maximum: 0.20



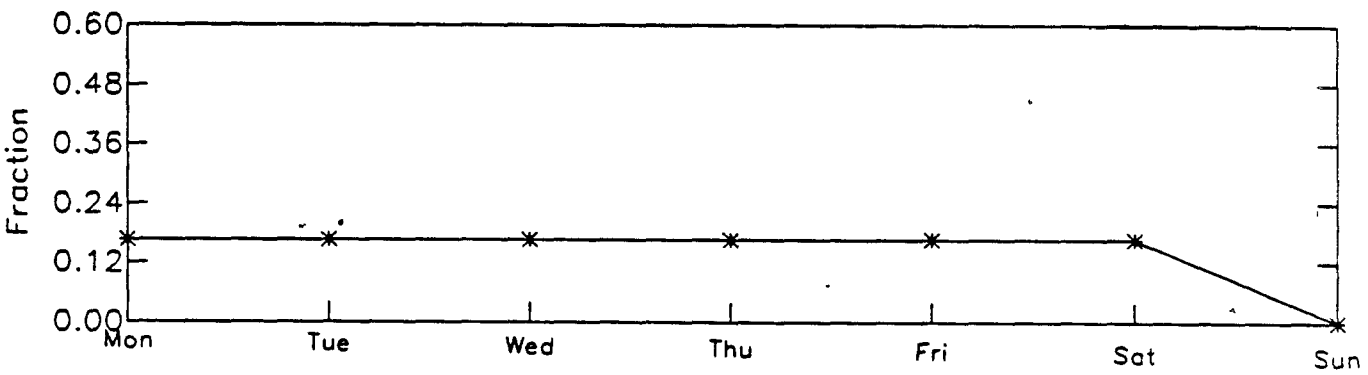
PROFILE: Wed Oct 7 22:09:42 1992

TEMPORAL PROFILE
/WEEKLY/

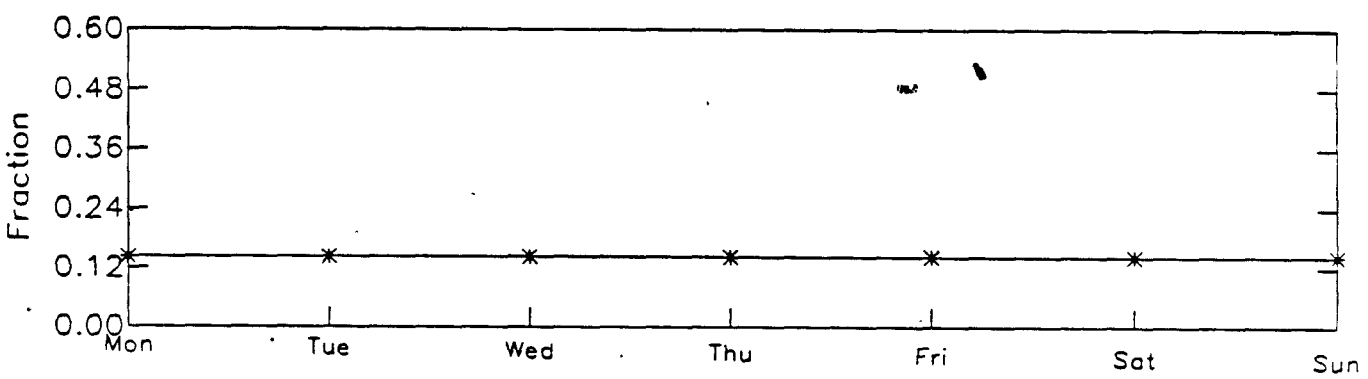
Profile #: 5 Maximum: 0.20



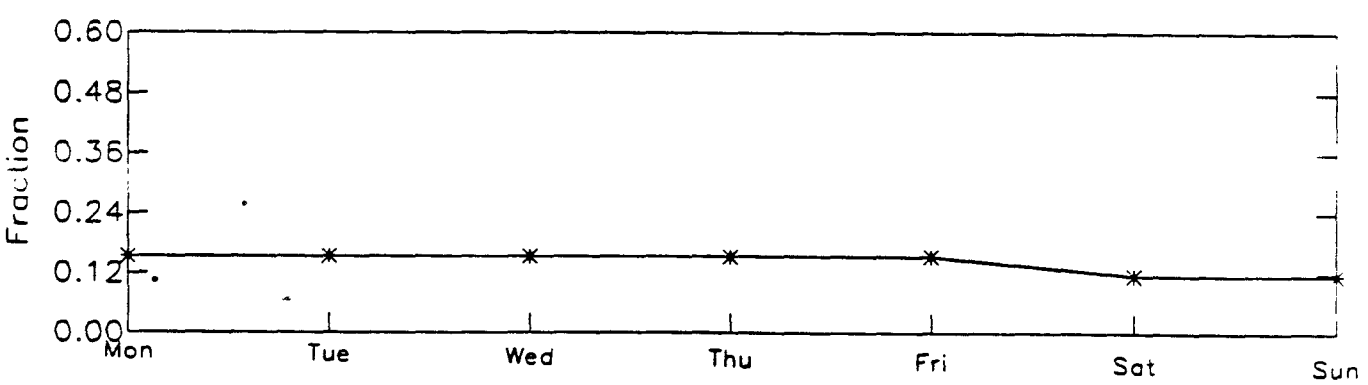
Profile #: 6 Maximum: 0.17



Profile #: 7 Maximum: 0.14



Profile #: 13 Maximum: 0.15

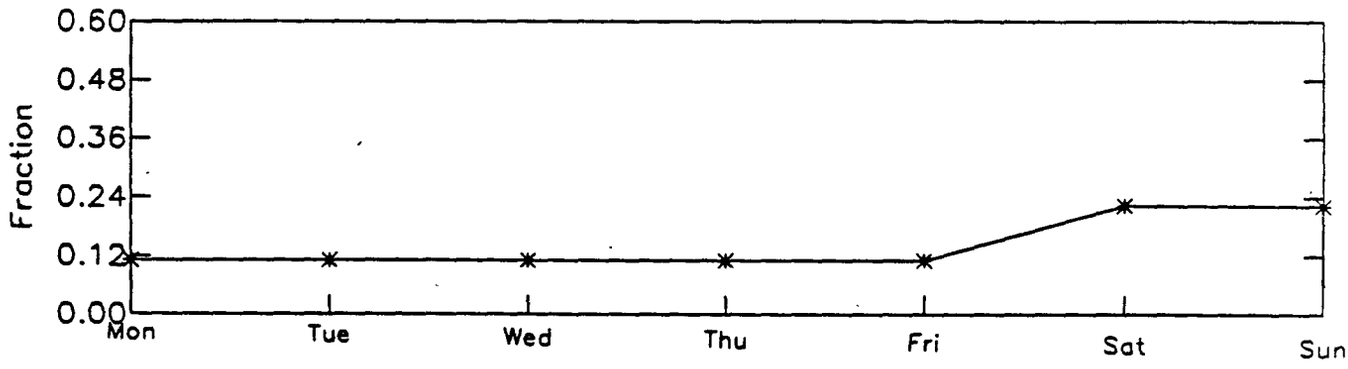


PROFILE: Wed Oct 7 22:09:42 1992

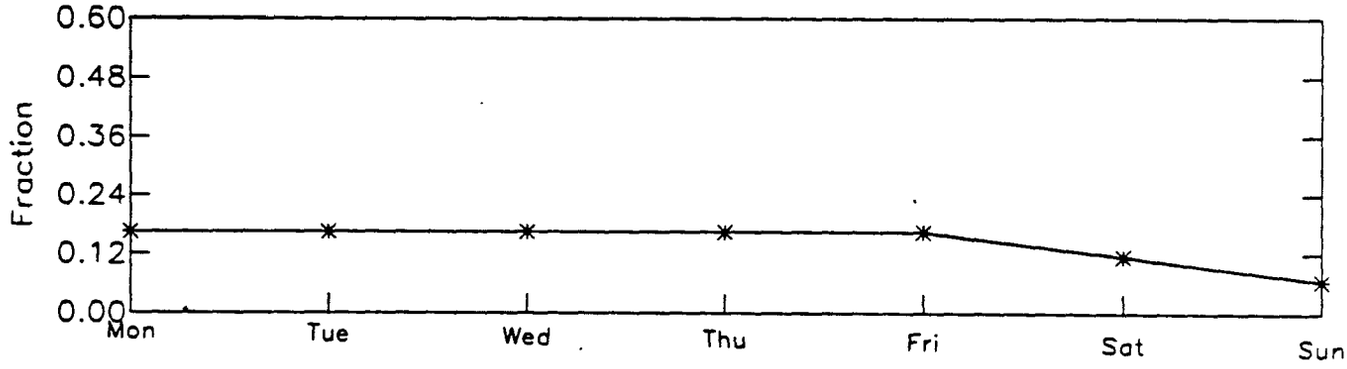
TEMPORAL PROFILE
/WEEKLY/

EPS Temporal Profiles

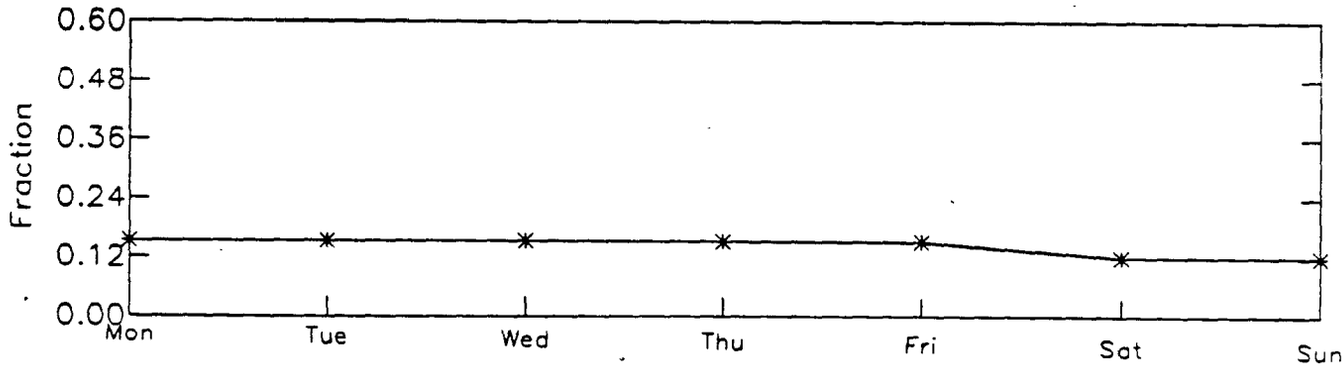
Profile #: 21 Maximum: 0.22



Profile #: 22 Maximum: 0.16



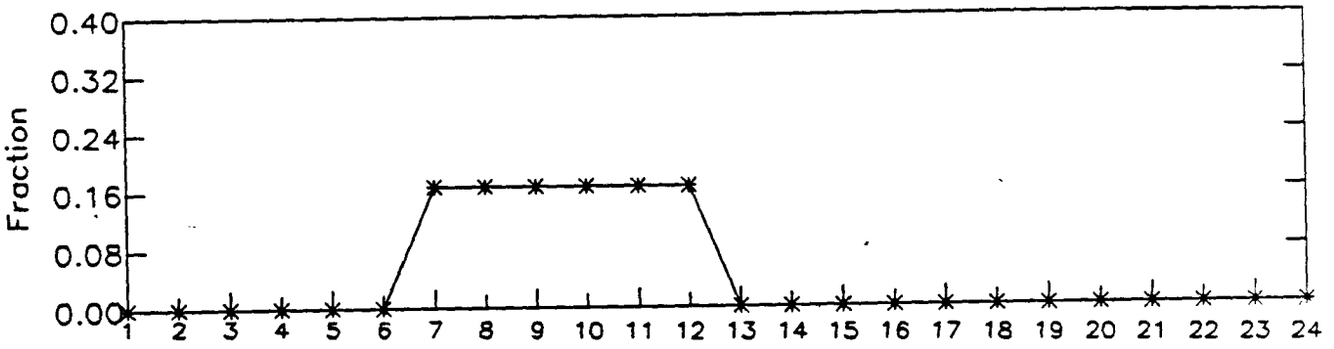
Profile #: 23 Maximum: 0.15



/DIURNAL WEEKDAY/

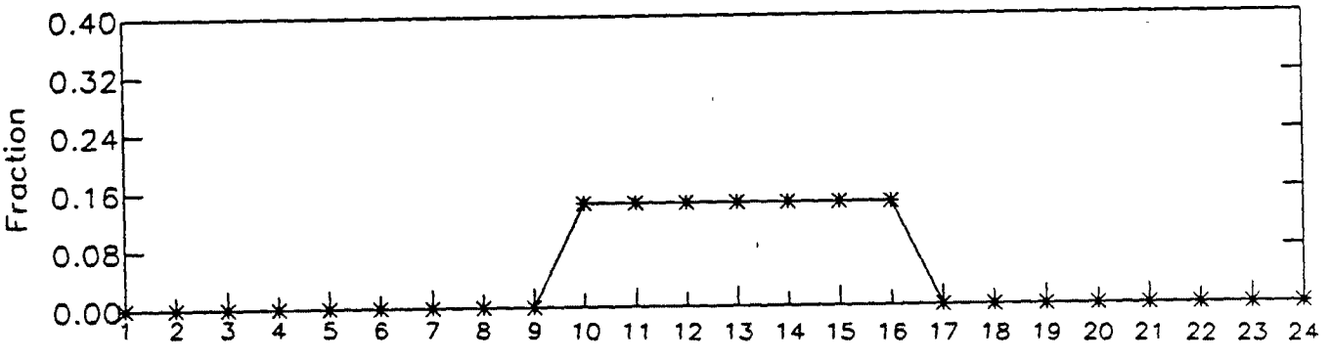
Profile #: 6

Maximum: 0.17



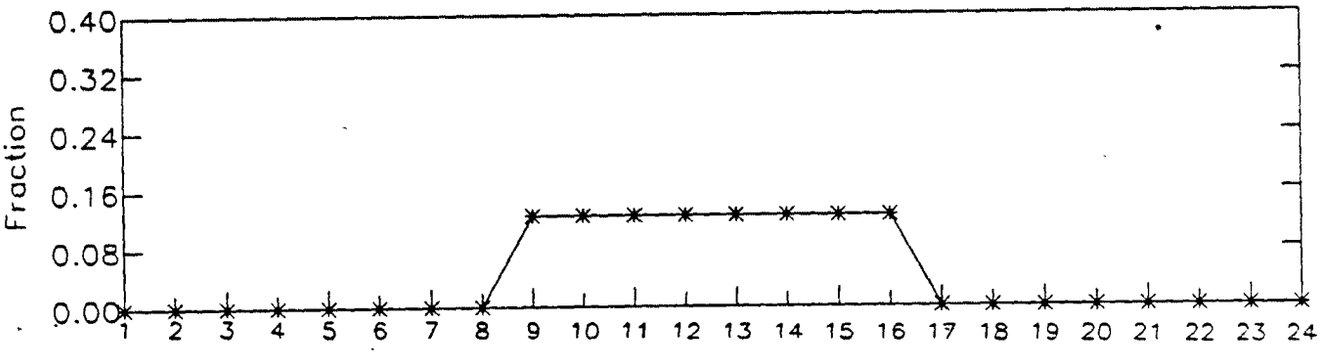
Profile #: 7

Maximum: 0.14



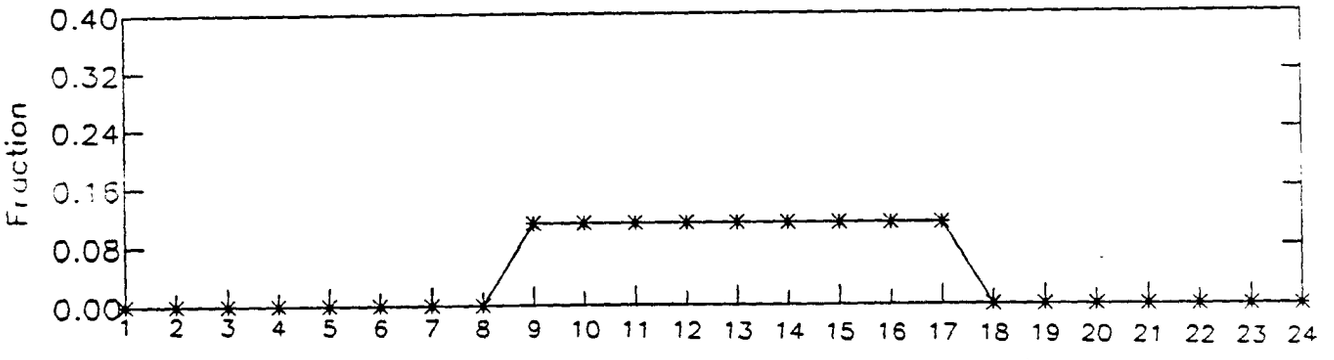
Profile #: 8

Maximum: 0 12



Profile #: 9

Maximum: 0.11



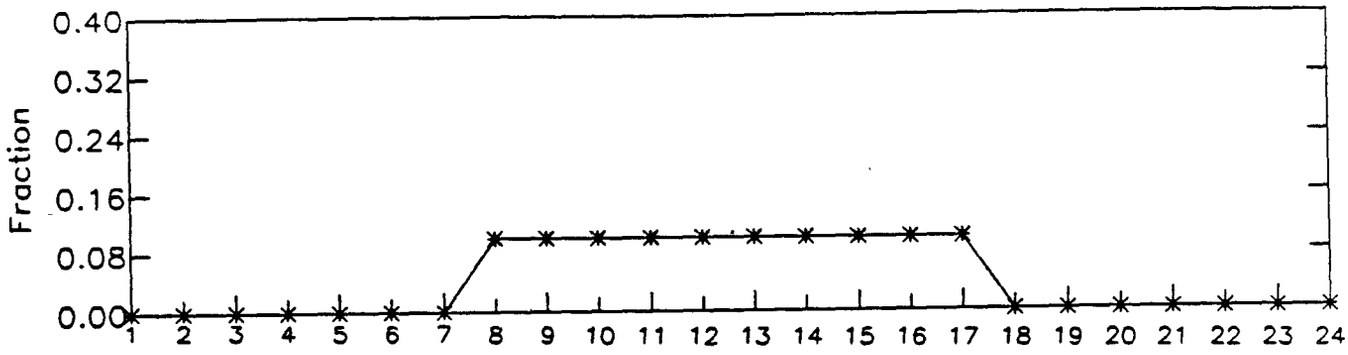
PROFILE. Wed Oct 7 22:09:44 1992

TEMPORAL PROFILE

/DIURNAL WEEKDAY/

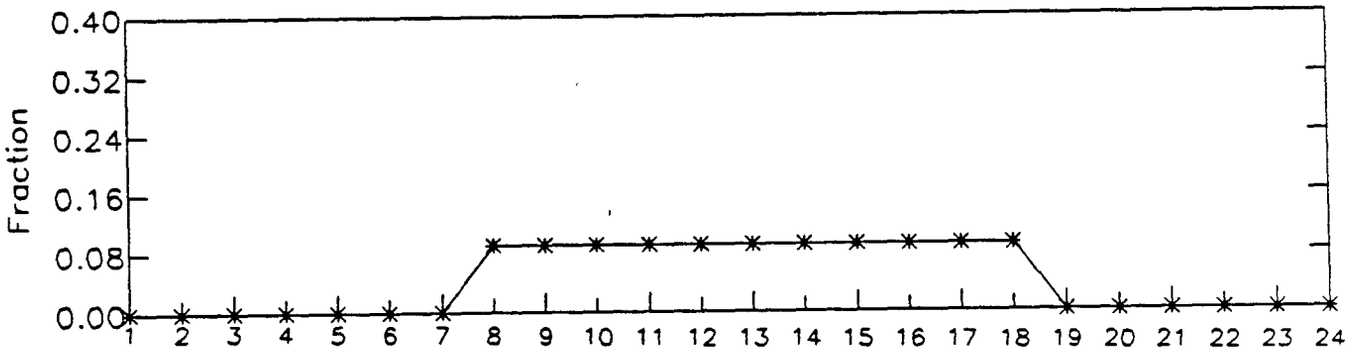
Profile #: 10

Maximum: 0.10



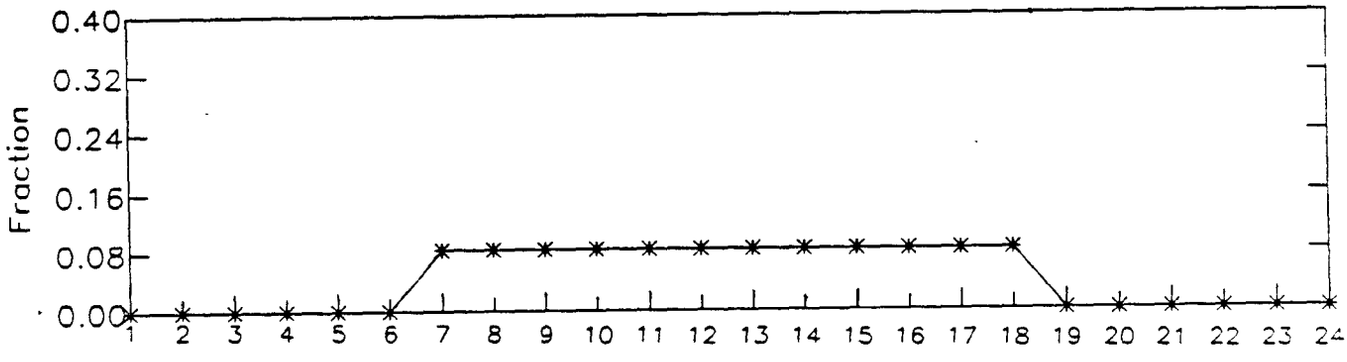
Profile #: 11

Maximum: 0.09



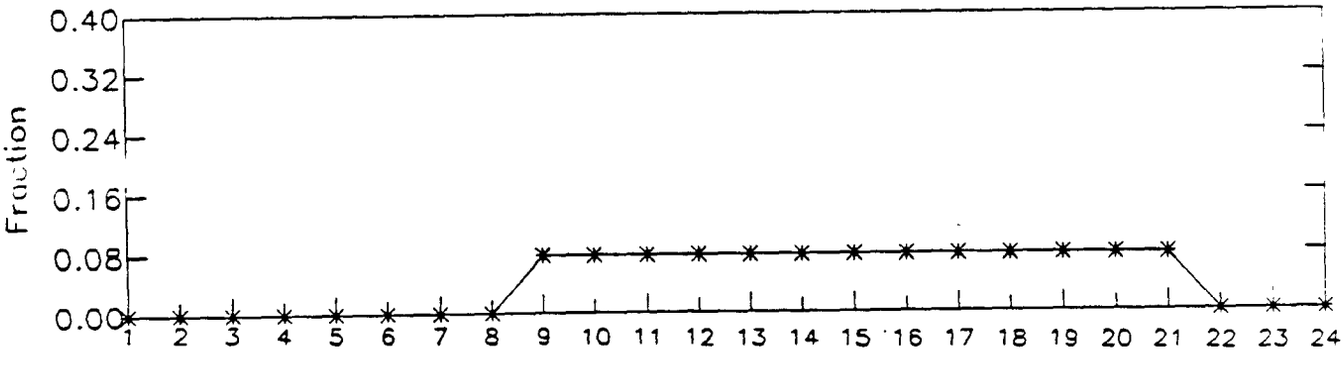
Profile #: 12

Maximum: 0.08



Profile #: 13

Maximum: 0.08

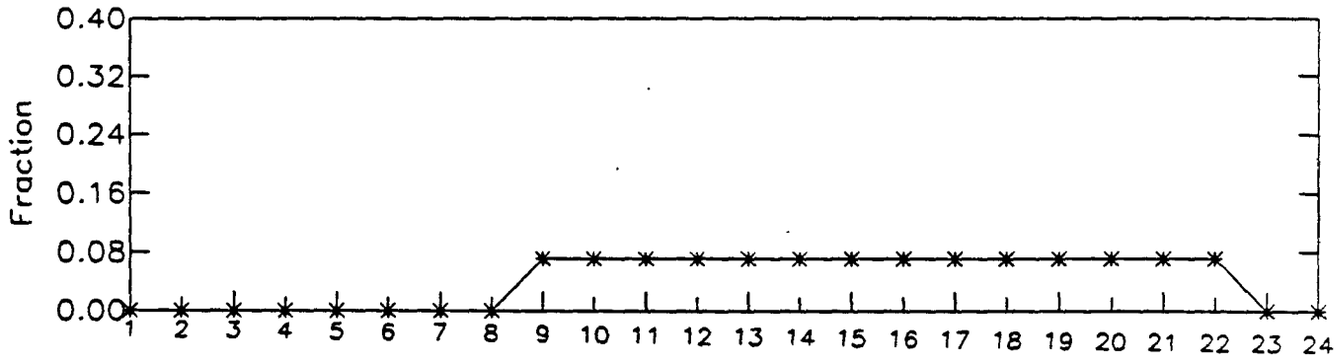


PROFILE: Wed Oct 7 22:09:45 1992

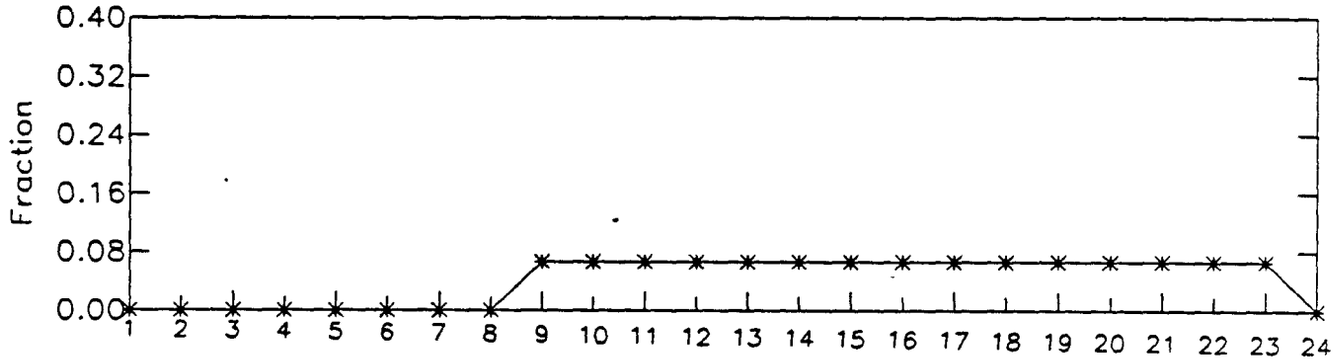
TEMPORAL PROFILE
/DIURNAL WEEKDAY/

EPS Temporal Profiles

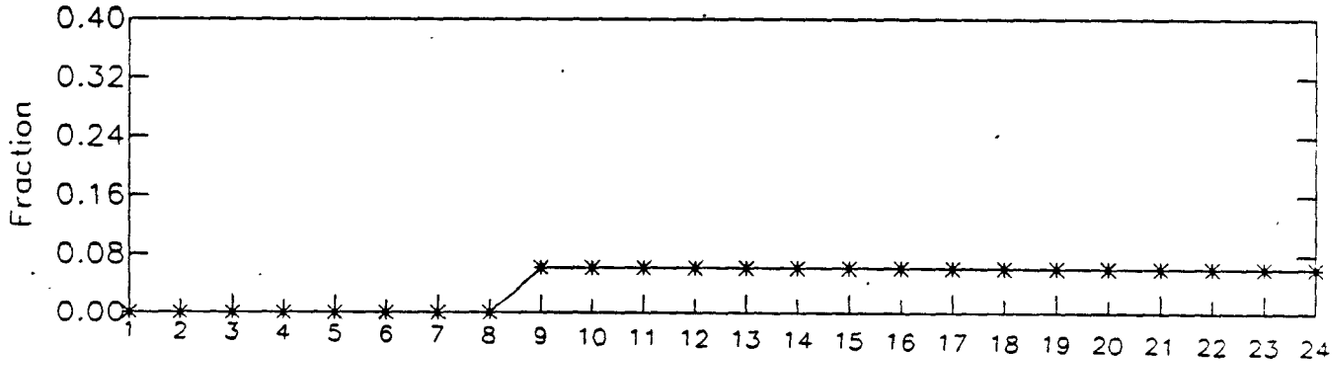
Profile #: 14 Maximum: 0.07



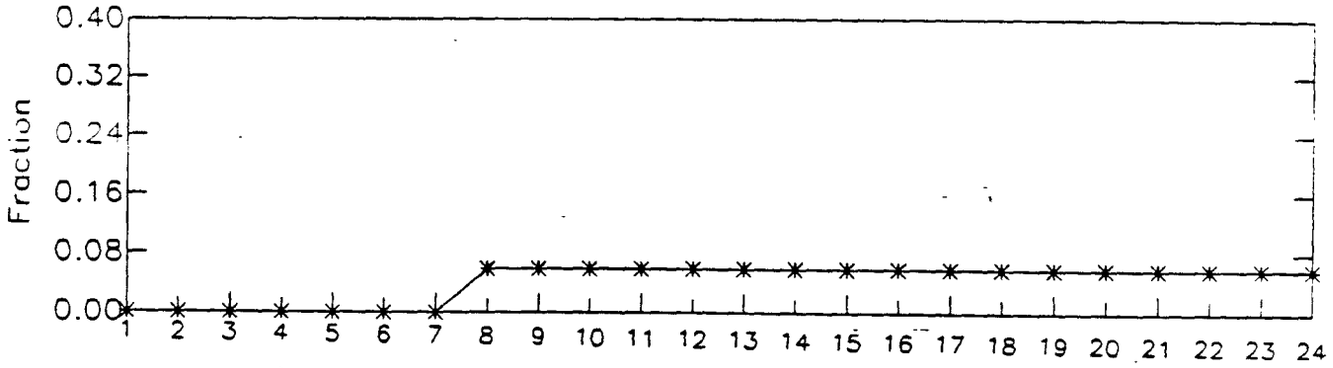
Profile #: 15 Maximum: 0.07



Profile #: 16 Maximum: 0.06



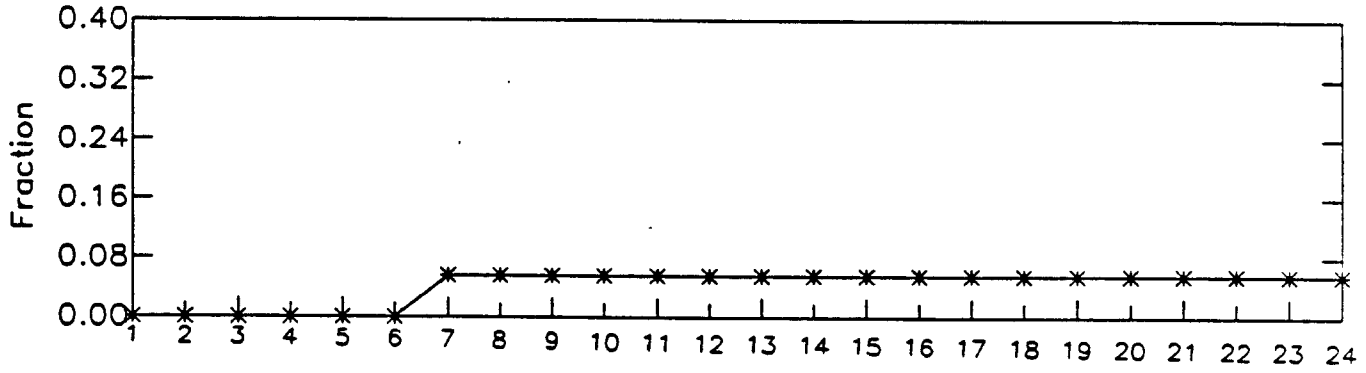
Profile #: 17 Maximum: 0.06



TEMPORAL PROFILE
/DIURNAL WEEKDAY/

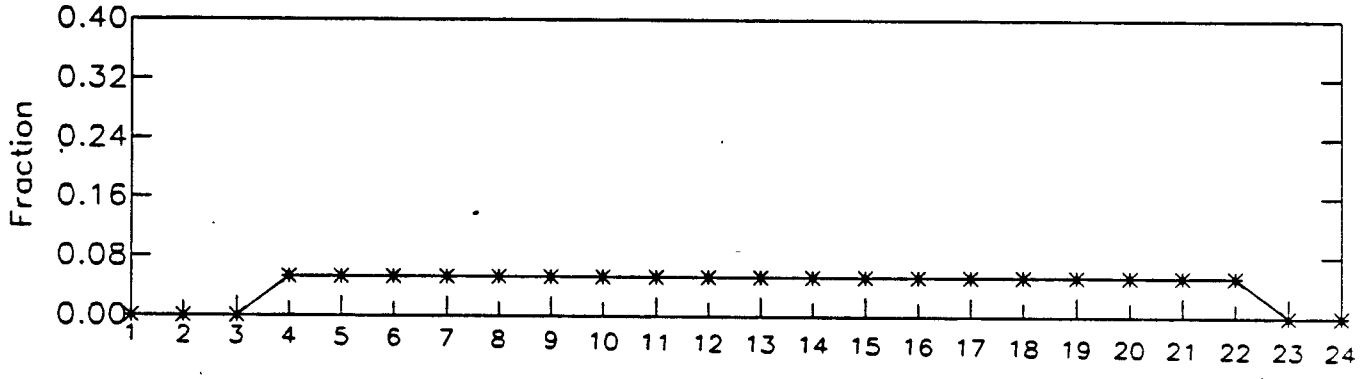
Profile #: 18

Maximum: 0.06



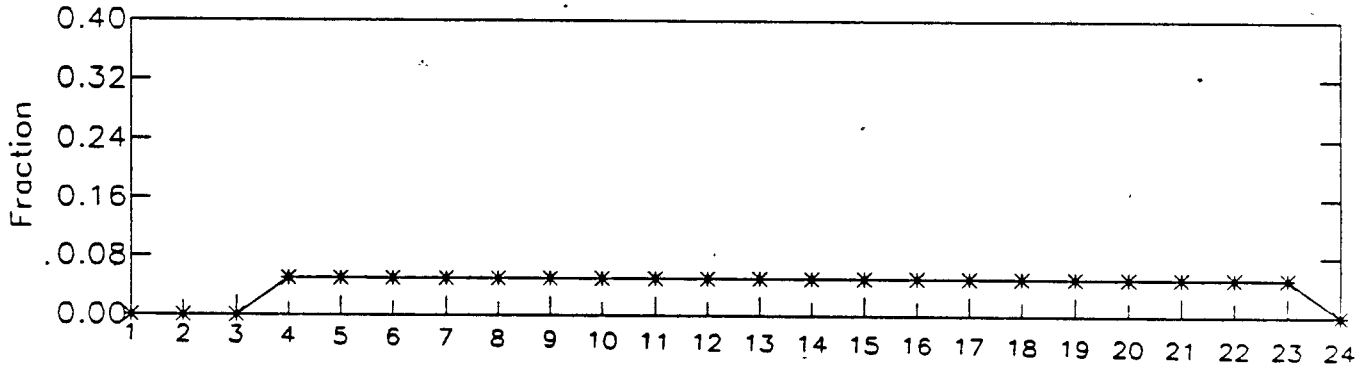
Profile #: 19

Maximum: 0.05



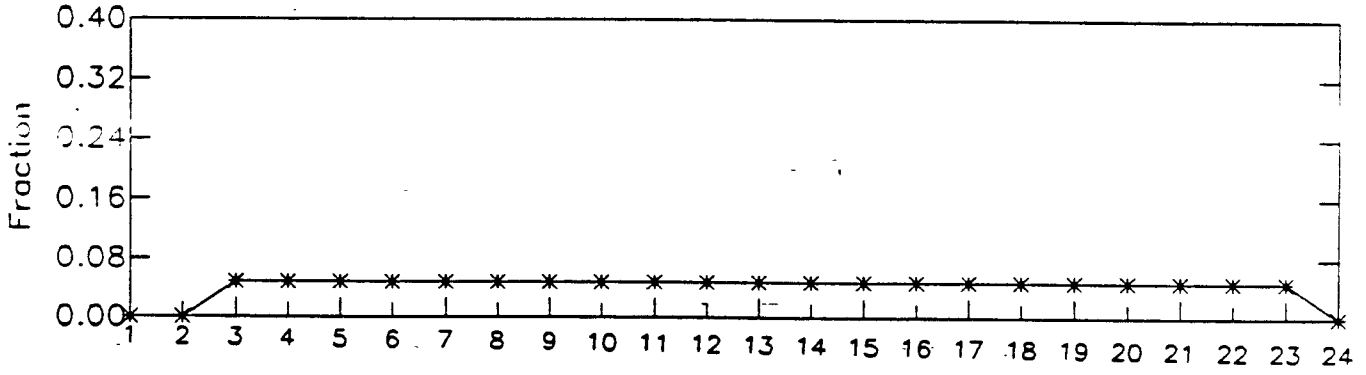
Profile #: 20

Maximum: 0.05



Profile #: 21

Maximum: 0.05

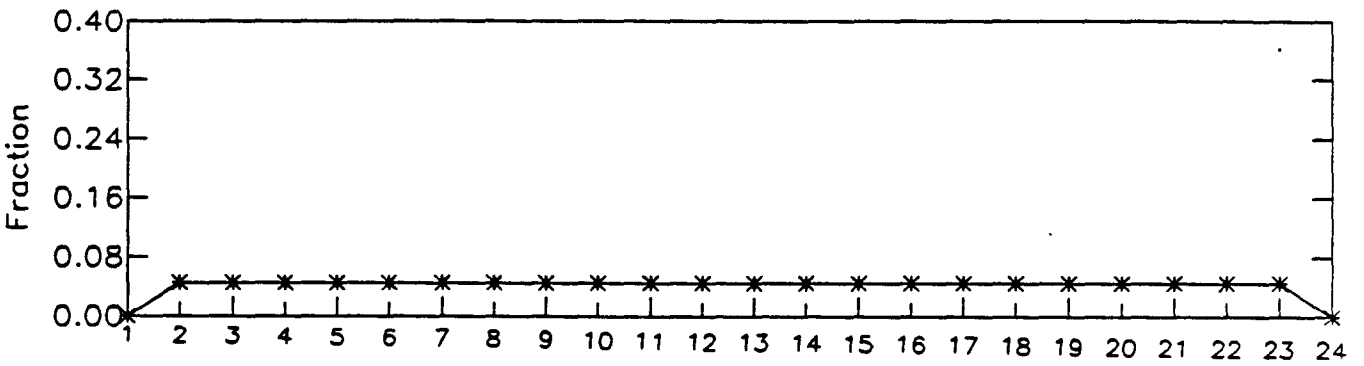


PROFILE: Wed Oct 7 22.09.45 1992

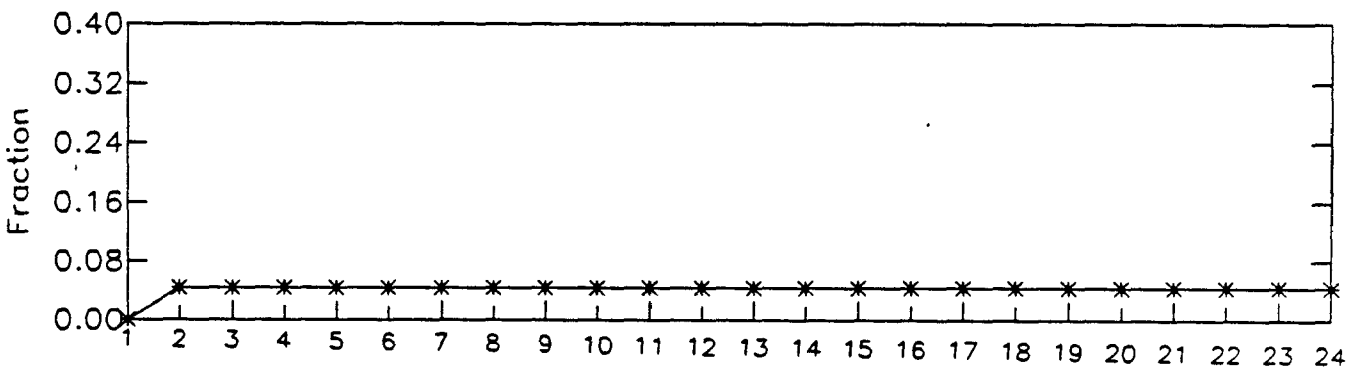
TEMPORAL PROFILE
/DIURNAL WEEKDAY/

EPS Temporal Profiles

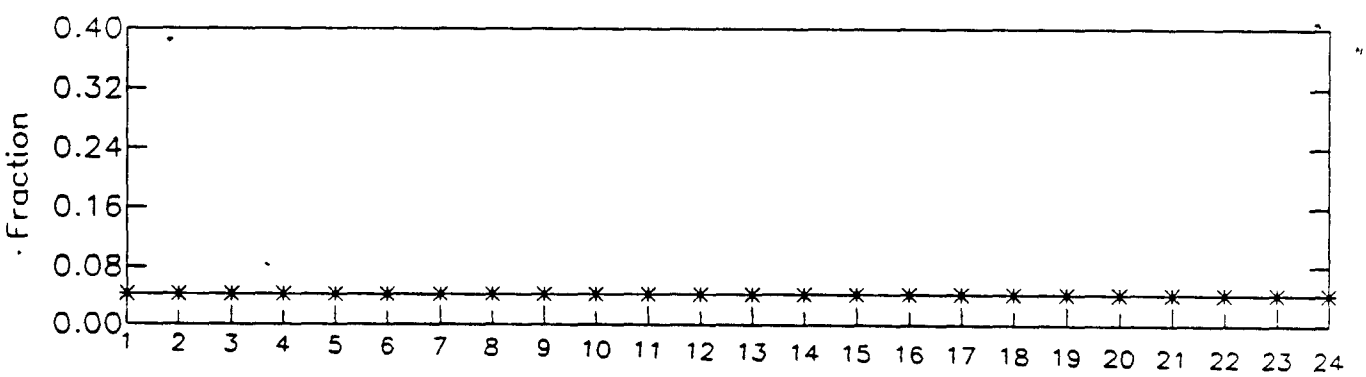
Profile #: 22 Maximum: 0.05



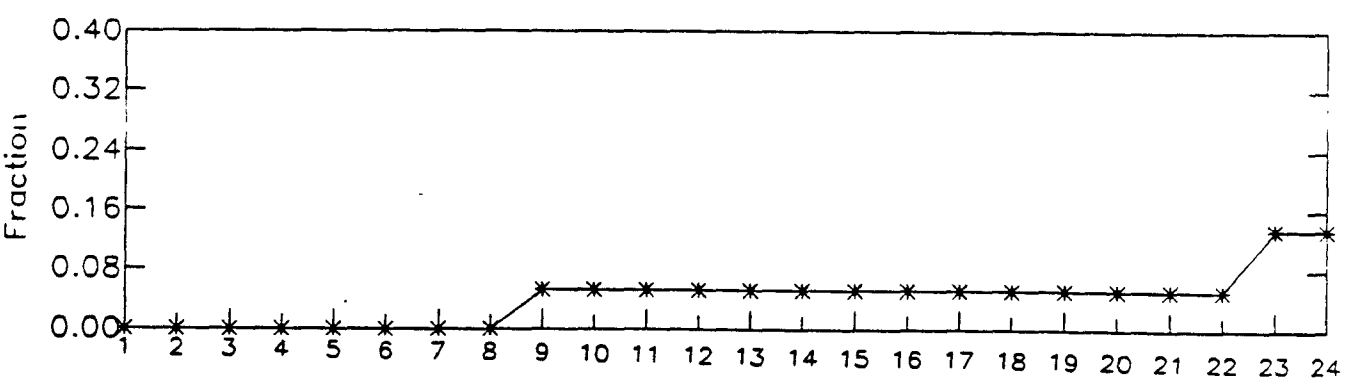
Profile #: 23 Maximum: 0.04



Profile #: 24 Maximum: 0.04



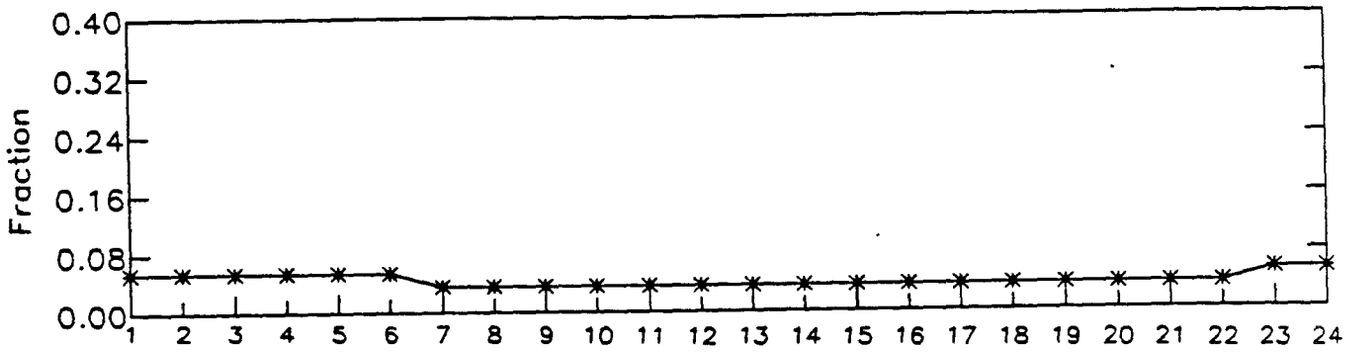
Profile #: 26 Maximum: 0.13



TEMPORAL PROFILE
/DIURNAL WEEKDAY/

Profile #: 27

Maximum: 0.05



Profile #: 31

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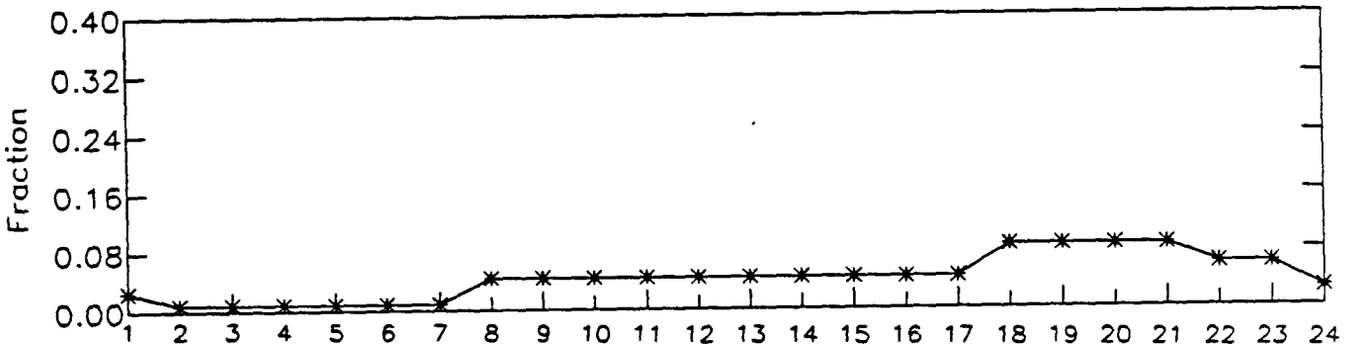

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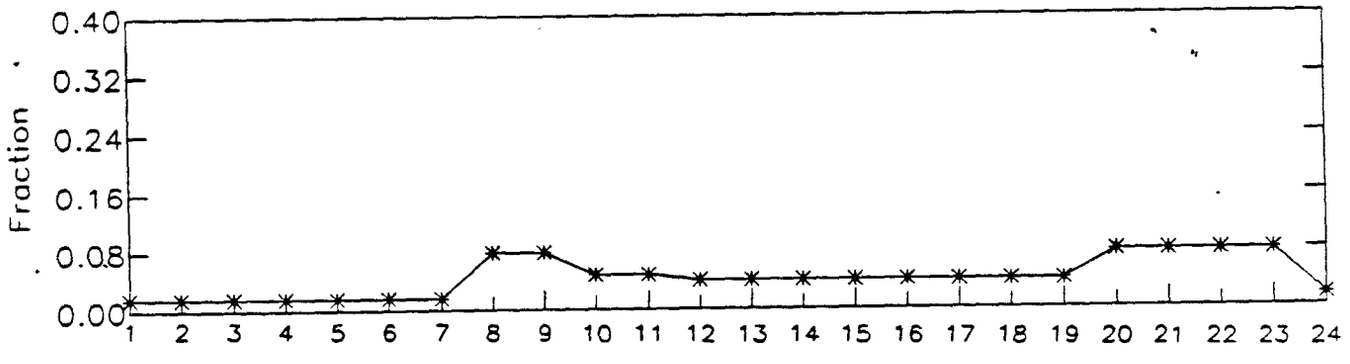

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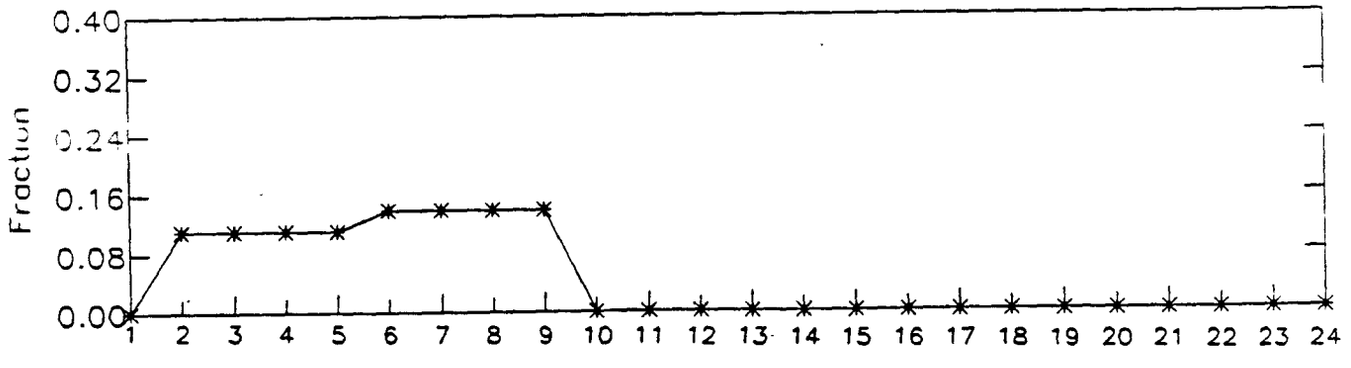

PROFILE: Wed Oct 7 22.09.46 1992

TEMPORAL PROFILE
/DIURNAL WEEKDAY/

EPS Temporal Profiles

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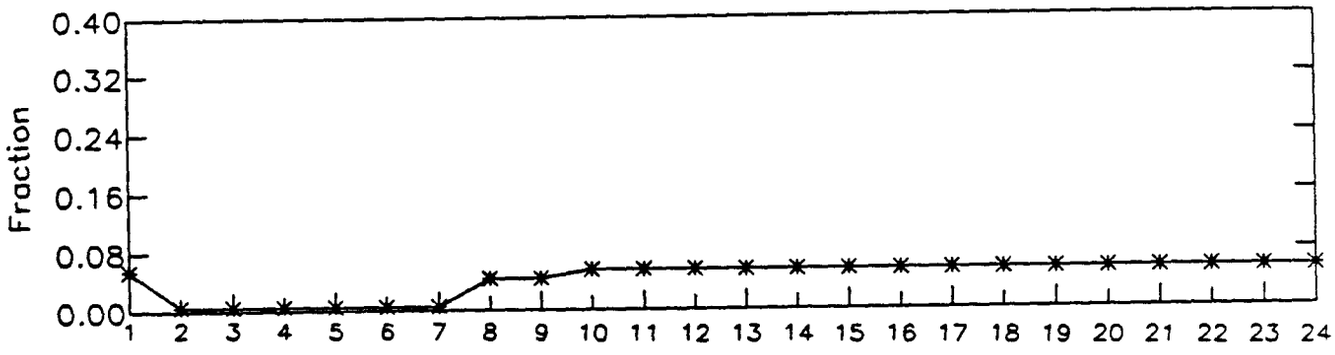
Maximum: 0.05



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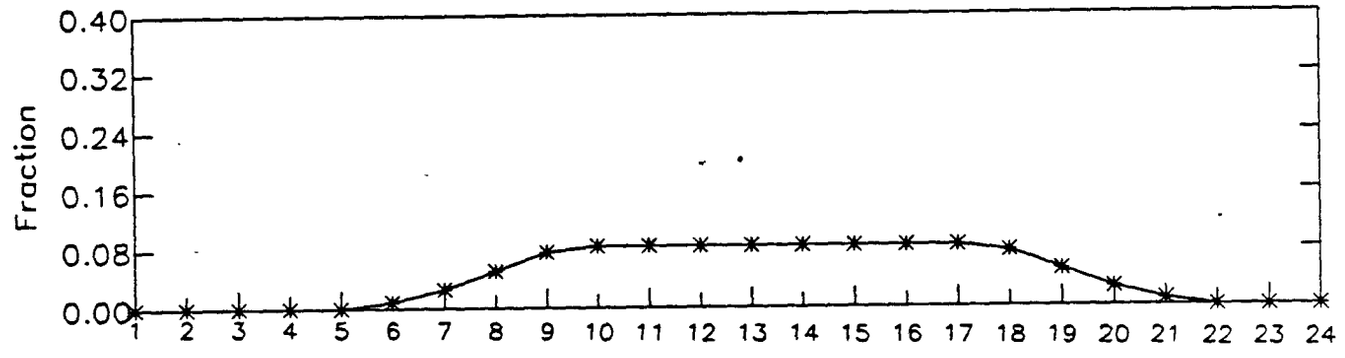
Maximum: 0.08



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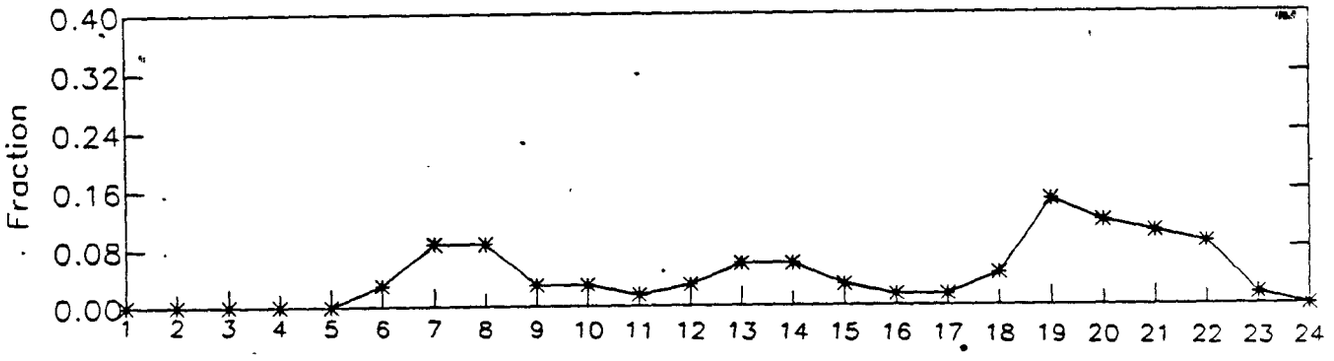

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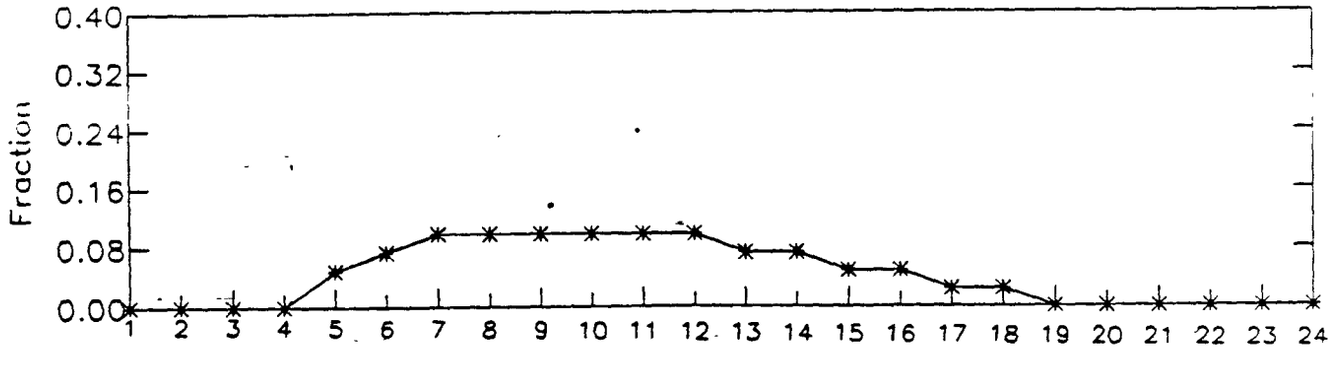
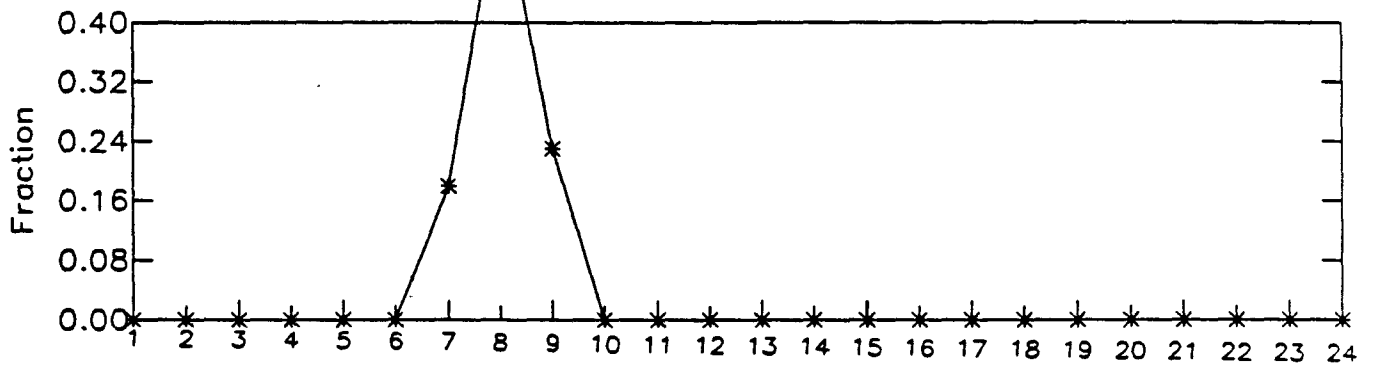


TEMPORAL PROFILE
/DIURNAL WEEKDAY/

Profile #: 41 Maximum: 0.59



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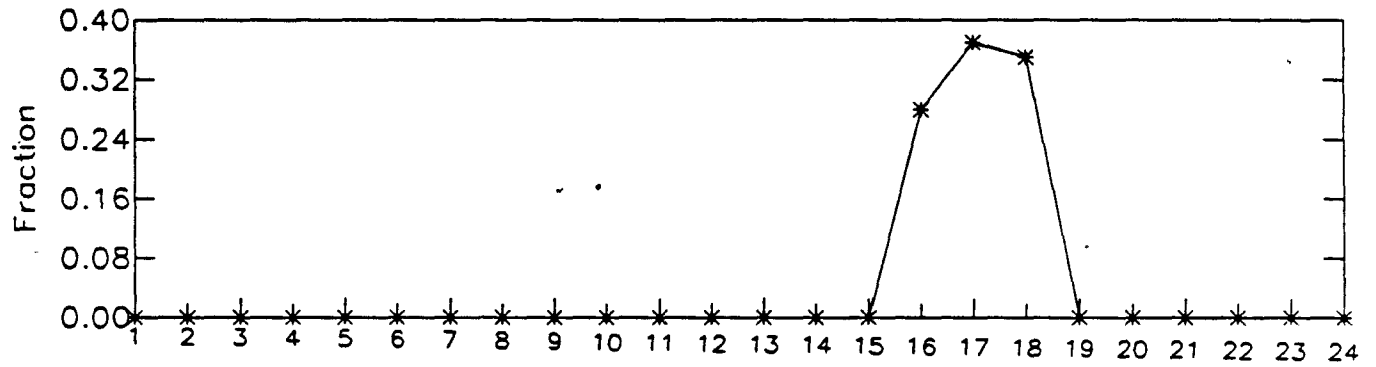

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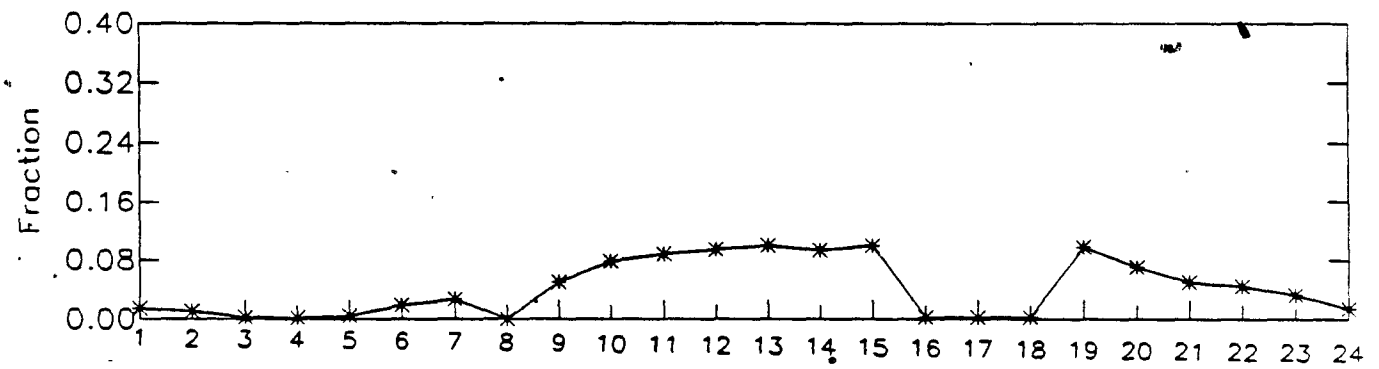

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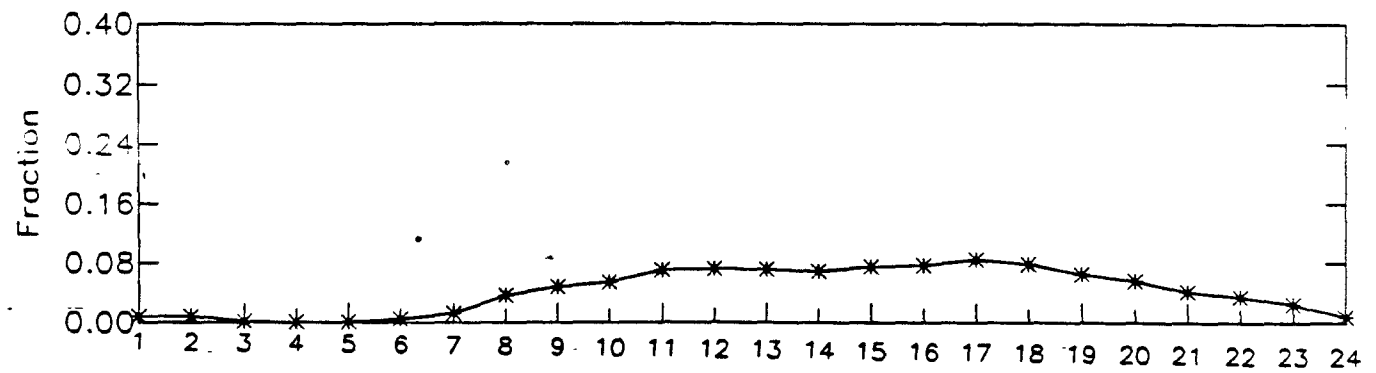


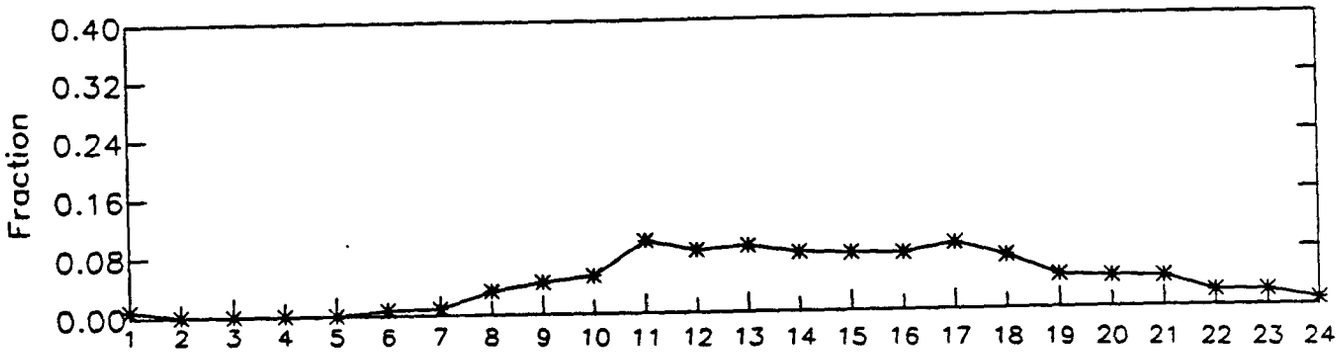
PROFILE: Wed Oct 7 22:09:46 1992

TEMPORAL PROFILE /DIURNAL WEEKDAY/

EPS Temporal Profiles

Profile #: 48

Maximum: 0.10



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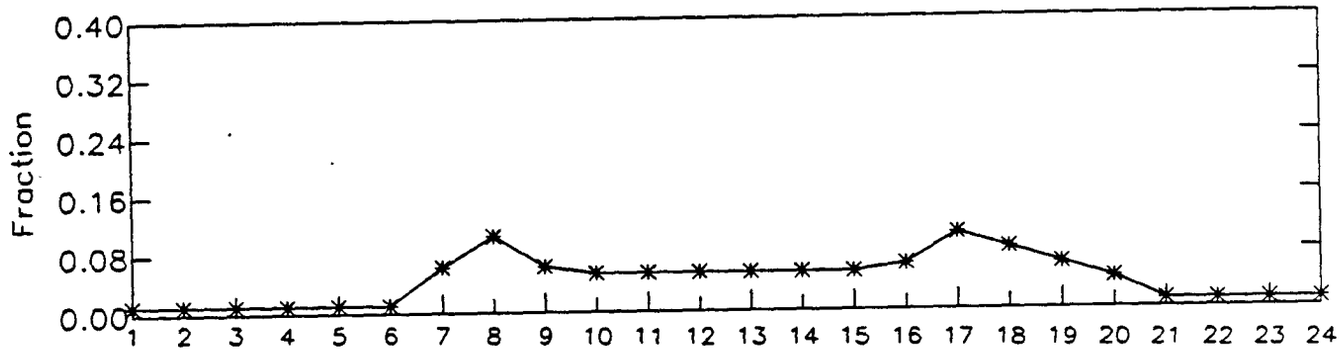

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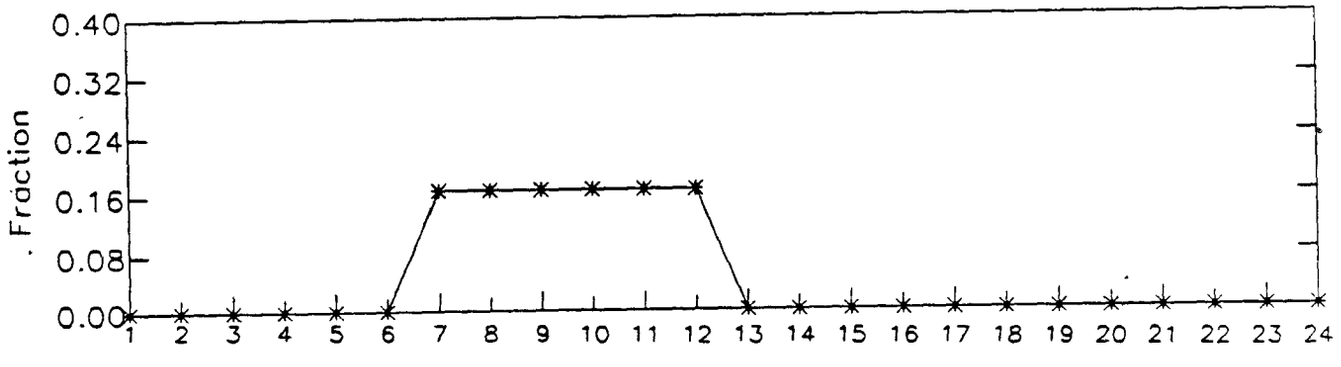

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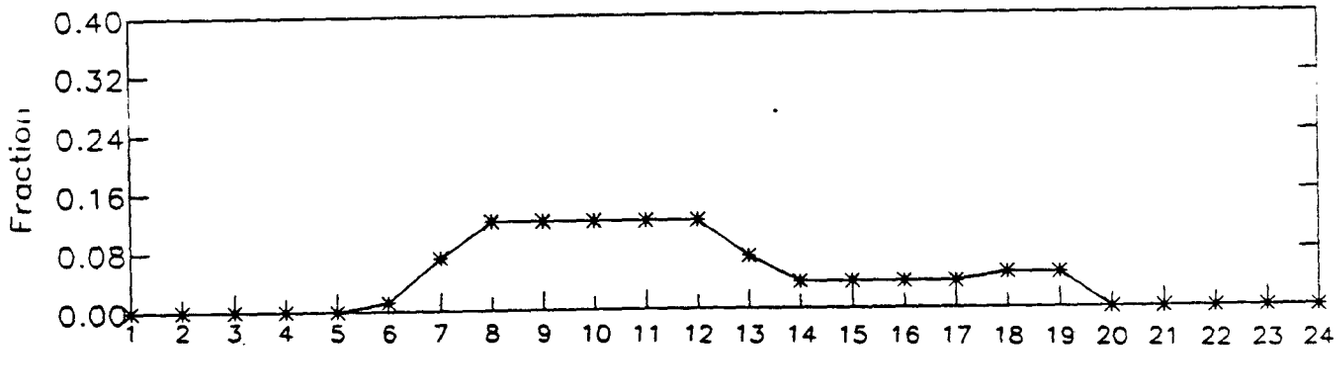

TEMPORAL PROFILE
/DIURNAL WEEKDAY/

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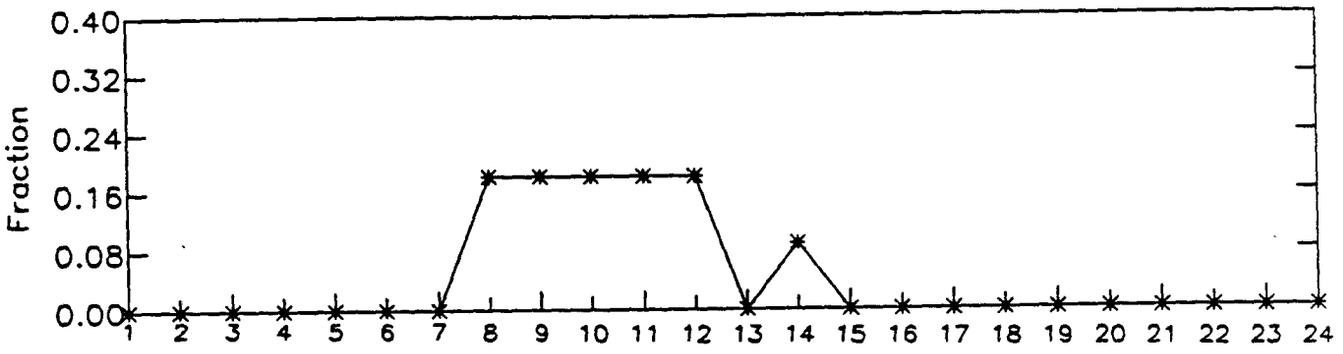
Maximum: 0.18



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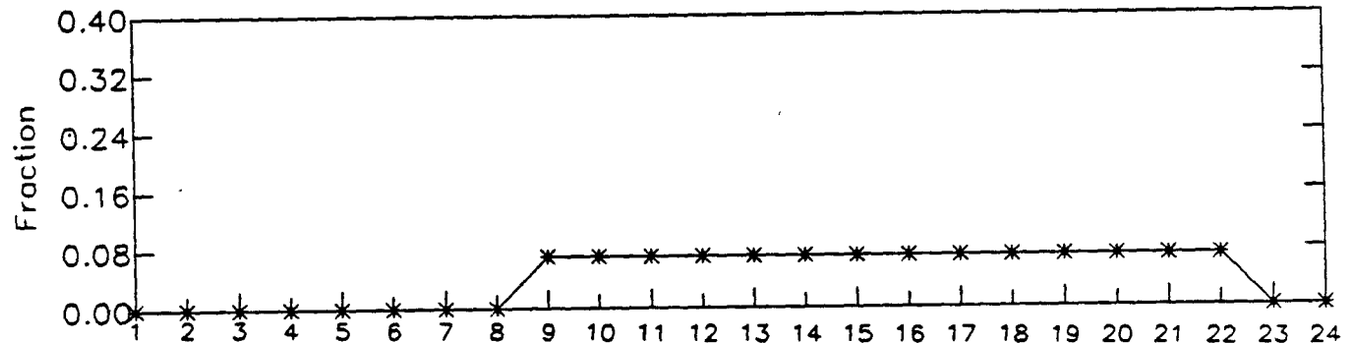

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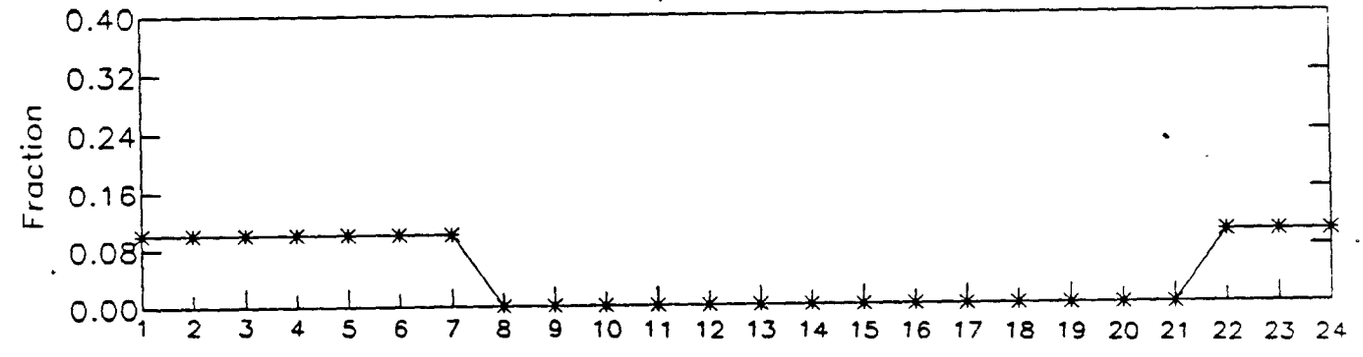
Maximum: 0.10



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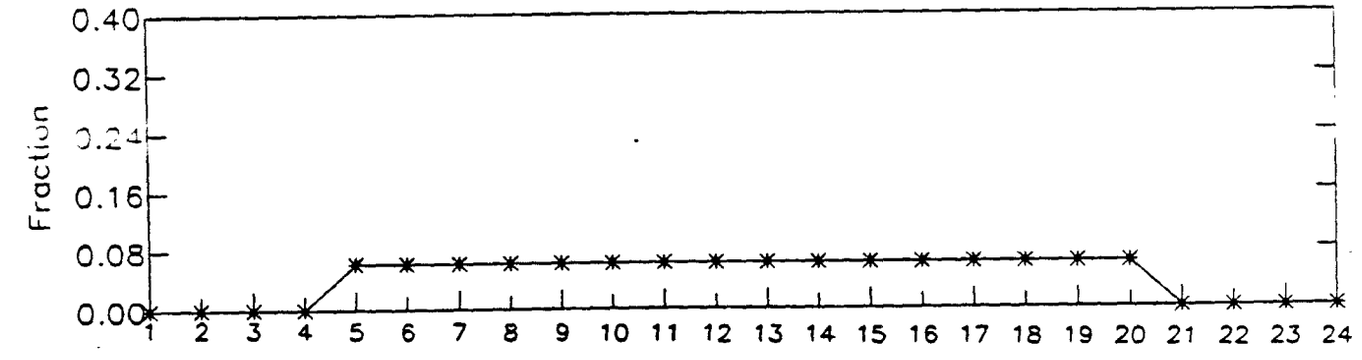
Maximum: 0.06



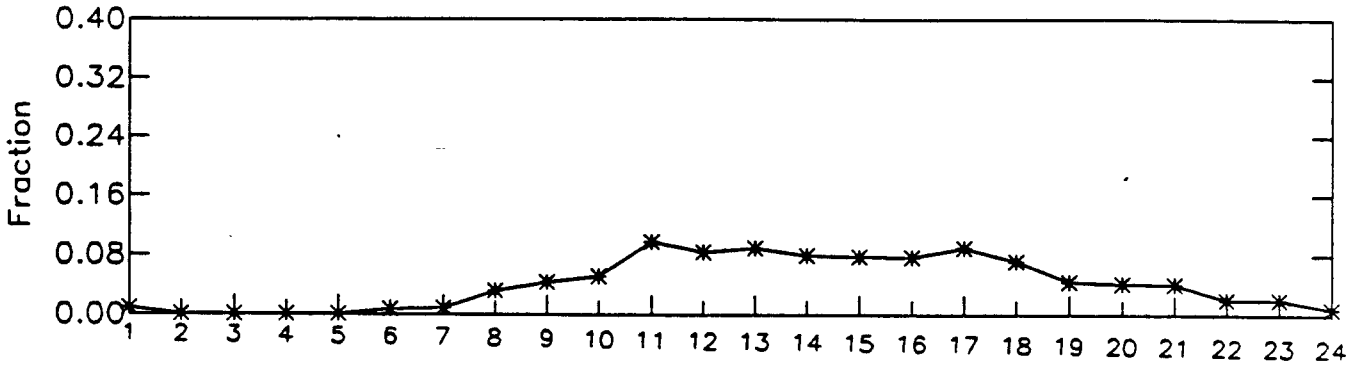
PROFILE: Wed Oct 7 22:09:47 1992

TEMPORAL PROFILE
/DIURNAL WEEKEND/

EPS Temporal Profiles

Profile #: 50

Maximum: 0.10



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(Please read Instructions on the reverse before completing)

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454/R-92-026		

4. TITLE AND SUBTITLE	5. REPORT DATE
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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 compounds (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 is the second revision of this volume, which updates the versions released in 1979 (EPA-450/4-79-018) and 1991 (EPA-450/4-91-014).

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
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