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Total Risk Integrated Methodology (TRIM) Air Pollutants Exposure Model Documentation (TRIM.Expo / APEX, Version 4.3)

Volume I: User's Guide

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Total Risk Integrated Methodology (TRIM) Air Pollutants Exposure Model Documentation (TRIM.Expo / APEX, Version 4.3). Volume I: User's Guide

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Health and Environmental Impacts Division
Research Triangle Park, North Carolina

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CHAPTER 1. INTRODUCTION

1.1 Overview of the APEX Model

The Air Pollutants Exposure model (APEX) is part of EPA's overall Total Risk Integrated Methodology (TRIM) model framework (EPA, 1999). TRIM is a time series modeling system with multimedia capabilities for assessing human health and ecological risks from hazardous and criteria air pollutants; it has been developed to support evaluations with a scientifically sound, flexible, and user-friendly methodology. The TRIM design includes three modules:

- Environmental Fate, Transport, and Ecological Exposure module (TRIM.FaTE);
- Human Inhalation-Dietary-Dermal Exposure module (TRIM.Expo); and
- Risk Characterization module (TRIM.Risk).

APEX is the inhalation exposure component of TRIM.Expo. The APEX model is a multipollutant, population-based, stochastic, microenvironmental model that can be used to estimate human exposure via inhalation for criteria and air toxics pollutants. APEX is designed to estimate human exposure to criteria and air toxic pollutants at the local, urban, and consolidated metropolitan level. The current release of the model is Version 4. Human exposure to a contaminant is defined as "contact at a boundary between a human and the environment at a specific contaminant concentration for a specific interval of time" (National Research Council, 1991). For air pollutants, the contact boundaries are nasal and oral openings in the body. Dose is the amount actually received, or absorbed, in the body, leading to physiological effects. Pollutant exposures are estimated in a microenvironmental model by treating each individual's activities as a sequence of *events*, which are periods with known starting and ending times in particular microenvironments. A *microenvironment* is a defined space with relatively homogeneous air pollution concentration for a simulated individual. "Indoor kitchen," "outdoor parking lot," or "in vehicle" are examples of microenvironments. The pollutant concentrations in the air in each microenvironment are estimated from ambient air pollutant concentrations and parameters specific to each microenvironment and each pollutant. A person's inhalation exposures for a time interval are the pollutant concentrations in the microenvironment that person for that interval multiplied by the length of the interval.

The APEX model uses the personal profile approach to generate simulated individuals, for whom exposure time series are calculated. The *profile* is a description of the characteristics of an individual that may affect their activities, their locations, or the concentrations in the microenvironments that they encounter. Typically, the profile includes demographic variables such as age, gender, and employment, as well as physiological variables such as height and weight, and finally some situational variables such as living in a house with a gas stove or air conditioning. The situational variables are used to help determine the microenvironmental concentrations, and the physiological variables are used in the determination of ventilation rate and dose. The demographic variables are used in the selection of *activity diaries* from EPA's Consolidated Human Activity Database (CHAD, McCurdy et al. 2000) to represent the individual. (Note: CHAD is a comprehensive database of human activity studies, which is provided with APEX. However, APEX may utilize other human activity data at the discretion of the user. Throughout this document "CHAD" will be used to denote the human activity diaries, although the reader should note that other data could be used).

APEX calculates the exposure and dose time series for a user-specified number of profiles for any number of pollutants. If modeling the pollutant CO, APEX contains an algorithm for estimating the blood dose (percent carboxyhemoglobin, %COHb). APEX also contains an algorithm for modeling particulate matter (PM) dose. In the case of PM, dose is defined as the rate of mass deposition in the respiratory system. If modeling any other pollutant, APEX calculates dose as Exposure*Ventilation (see *Volume II* for details of the dose algorithms). Collectively, these profiles are intended to be a representative random sample of the population in a given study area. To this end, demographic data from the decennial census are used, so appropriate probabilities for any given geographical area can be derived. In APEX the demographic geographical units are called *sectors*. Using the standard input files provided with the model, each sector is a census tract. Ambient air quality and meteorology data for the study area are also required by the model; the area represented by an air quality monitor (or air quality model grid cell) is called an *air district*, and the area covered by a meteorological monitor (or meteorological model grid cell) is referred to as a *zone*. APEX matches up each sector in the study area with the closest air district and zone to provide the data necessary to simulate exposure and dose for an individual.

For each simulated person (profile), the following general steps are performed:

- Select the profile variables to characterize the person
- Construct the event sequence by selecting a sequence of appropriate activity diaries for the person (using demographic variables)
- For each pollutant, calculate the concentrations in the microenvironments (using situational variables)
- For each pollutant, calculate the person's exposure and dose for each event
- Summarize the results for that profile

The APEX model reports the results for each profile on various output files (some of which are pollutant-specific), described in detail later in this guide. Once all the profiles have been simulated, the model produces a set of summary tables for each pollutant that indicate the distributions of exposure and dose across all the profiles.

Model enhancements and other changes are occasionally made to APEX, and thus users are encouraged to revisit the download website for notices of these changes. Comments and suggestions for improvements to the model or the input data provided with the model should be addressed to John Langstaff, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711 (email: langstaff.john@epa.gov).

1.2 Scope and Organization of This Guide

The documentation of the APEX model is currently divided into two volumes. *Volume I: User's Guide* (this document) is designed to be a hands-on guide to the model. It focuses on how to run the APEX computer model, develop the appropriate input files, and understand the model output files.

Volume II: Technical Support Document describes the scientific basis of the APEX model and provides scientific background for the model algorithms. It covers the methods implemented in APEX for calculating microenvironmental concentrations, modeling ventilation, estimating dose, and assembling activity diaries.

Additional volumes or revisions to these volumes may be developed as APEX is upgraded, example applications are developed, or other needs arise.

The rest of *Volume I* is organized into the following chapters:

- *Chapter 2, Installing APEX*—Describes the hardware requirements and provides instructions for installing APEX.
- *Chapter 3, Running APEX*—Provides step-by-step instructions on starting single or multiple APEX simulations.
- *Chapter 4, Input Files*—Provides a description of the format, data, and options for each of the APEX input files.
- *Chapter 5, Output Files*—Provides a description of the format and data associated with each of the APEX output files.

CHAPTER 2. INSTALLING APEX

APEX is written in Fortran 90 using only standard Fortran 90 routines and conventions to allow portability to different operating systems and compilers. APEX has been tested on Windows XP, 2000, NT, and 98 operating systems as well as Linux.

In addition to providing flexibility in modeling options, the APEX code is specifically designed for fast execution time and reasonable memory requirements.

We recommend running APEX on a computer with at least:

- 512 MB of RAM;
- 600 MHz processor; and
- 1000 MB of available hard drive space.

The input files supplied with APEX will require 320 MB of hard drive space, and the additional input files created by the user may take up another 1-10 MB of space.

APEX run time on a PC with a 3.6 GHz Pentium 4 CPU and 2 GB of RAM, running Windows XP, is 6 hours for a one-year single-pollutant simulation of 100,000 individuals in a large metropolitan area. The combined size of the output files from this simulation is 150 MB, unless detailed hourly data are requested, in which case the output files can take up more than 5,000 MB.

To install APEX, download the APEX executable and the input database files from http://www.epa.gov/ttn/fera. These files can be placed in directories of the user's choice. No installation procedure is required unless APEX is to be run in the MIMS framework (http://www.epa.gov/ttn/fera/mims_download.html). At this time APEX Version 4 can not be run in MIMS.

CHAPTER 3. SETTING UP AND RUNNING APEX

This chapter, which describes the steps involved in setting up and running an APEX simulation, is organized as follows:

Section 3.1 Setting Up an APEX Simulation
Section 3.2 Overview of APEX Input and Output Files
Section 3.3 Overview of Model Settings and Options
Section 3.4 Running APEX in Batch Mode

3.1 Setting Up an APEX Simulation

This section describes the steps involved in performing an APEX simulation.

1. Select Model Options

After identifying the scope of the analysis, the user must decide which options to select. To determine the appropriate options for the application, the user must answer questions such as the following.

- How many pollutants do I want to model in a single run?
- Do I want to model worker commuting?
- How many profiles (or what percentage of the population) do I want to model?
- How many microenvironments do I want to model?
- How should I define my microenvironments?
- How should I select the activity diaries (i.e. do I randomly select a new diary every day for each simulated individual, or do I construct longitudinal diaries based on diary properties?)
- Which model settings should I select (e.g., model Daylight Savings Time? use air quality controls, or "rollbacks"?)
- What types of outputs do I want from the model?
- What time resolution do I want to use?

These options and others are described in more detail in Section 3.5.

2. Prepare Input Files

After deciding which model options to use and how to configure them, the next step in configuring an APEX simulation is to set up the input data files with the necessary data. One of these files, the *Simulation Control* file, is used to specify input and output file names and locations and the simulation settings. The remaining files contain the input data necessary to run APEX. The data contained in these remaining files varies depending on the configuration of the scenario to be modeled and the number of pollutants used. The input files are described in Chapter 4.

3. Configure the Simulation Settings

The final step in preparing an APEX simulation is to create the *Simulation Control* input file for the desired simulation settings. This file contains four sections:

- Input file names and locations;
- Output file names and locations;
- Pollutant parameters (including output table specifications); and
- Job parameters.

A detailed description of the data for each of the sections of the *Simulation Control* file is provided in Chapter 4.

***4. Running* APEX**

To perform an APEX simulation the user can run the model via one of the methods described in Section 3.4.

3.2 Overview of Input and Output Files

This section provides a brief overview of the input and output files associated with APEX. (For more detailed descriptions of the input and output files, refer to Chapters 4 and 5, respectively.) All of the input and output files used by APEX are ASCII text files; they can be read and/or modified by the user using a text editor or other software. Note, however, that certain files, such as the commuting input file and the hourly and events output files, may be very large (over 100 megabytes) and difficult for some text editors to handle.

3.2.1 Input Files

There are 20 types of APEX input data files. Most of these files are required; however, the *Diary Statistics* and *Prevalence* files are optional in some cases. With the exception of the *Population Data* and the *Air Quality Data* files, there is only one file of each type required for a simulation. The input file paths and names are designated in the *Simulation Control* file, using a "keyword" approach. APEX processes the file and searches for particular keywords followed by an equal sign and one or more values for the keyword. Table 3-1 lists each file type and the keyword that must be used to identify it. (Chapter 4 provides a detailed description of the approach and its syntax.)

The APEX input files are described in detail in Chapter 4.

3.2.2 Output Files

There are a total of 9 possible APEX output file types. These files contain such information as (1) a summary of the properties of the simulated persons, (2) hourly or event-level exposures, doses, and breathing data for the simulated profiles, (3) hourly or daily values of microenvironmental parameters and pollutant concentrations, (4) dose and exposure summary tables for the modeled population, and (5) exposure statistics for the modeled microenvironments. The creation of some of the output files is dependent on settings in the *Simulation Control* file, which also contains the path and file name for each output file. Table 3-1 lists each of the output data files and their corresponding keywords. If an output file is specified with the same name and location as an existing file, the old files are overwritten. Therefore, if the user wishes to conduct a series of model runs, the output files for each run should be named differently or the output should be moved elsewhere before the next model run is submitted.

The APEX output files are covered in detail in Chapter 5.

Table 3-1. APEX Input and Output Files

File	Pollutant Specific?	Simulation Control File Keyword
Input Files		
Simulation Control File		-
Population Data Files		***POP***
Employment Probability File		***EMPLOY***
Commuting Flow File		***COMMUT***
Population Sector Location File		***SECTOR***
Air District Location File		***DISTRICT***
Air Quality Data File	YES	***QUALITY***
Meteorology Zone Location File		***ZONE***
Meteorology Data File		***METEOR***
MET Mapping File		***METSMAP***
MET Distribution File		***DISTRIB***
Physiological Parameters File		***PHYSIOL***
Ventilation File		***VENTIL***
Microenvironment Mapping (MEMap) File		***MEMAP***
Diary Questionnaire (DiaryQuest) File		***DIARYQUEST***
Diary Events (Diaryevents) File		***DIARYEVE***
Diary Statistics (Diarystat) File		***DIARYSTA***
Profile Functions File		***FUNCTIONS***
Microenvironment Descriptions File		***MICROENV***
Prevalence File		***PREV***
Output Files		
Log File		***LOG***
Hourly File		***HOUR***
Daily File		***DAILY***
Microenvironment Results File	YES	***MICRORES***
Profile Summary (Persons) File		***PSUM***
Microenvironment Summary File	YES	***MICROSUM***
Output Tables File	YES	***TABLE***
Sites File		***SITE***
Events File		***EVENT***
Timestep File		***TIMESTEP***

3.3 Overview of Model Settings and Options

This section briefly describes the primary settings and options available in APEX. These are specified by the user in the *Simulation Control* file or other input files. There are five general categories of settings and options in APEX:

- General Model Settings and Options;
- Study Area Location;
- Pollutants;
- Profiles;
- Microenvironments; and
- Outputs.

Table 3-2 describes the settings and options in each of these categories, how they are selected or changed, and the impact of changing a setting or option on the other input files. See Chapter 4 for additional details of input files and their content, how to edit or create them, and how they interact with other files.

Table 3-2. APEX Settings and Options

SETTING/OPTION	*How Option is Selected*	*Impact of Changing Default Setting on Other Input Files*
GENERAL MODEL SETTINGS AND OPTIONS		
Simulation start/end dates	Specified in YYYYMMDD format (e.g., 19960704 is July 4, 1996) using the ***Start_Date*** and ***End_Date*** keywords in the *Control* file. The user must define the appropriate start and end dates for an application.	The indicated start and end dates must be included in the date ranges included in the *Air district Location*, *Meteorology Zone Location, Meteorology Data*, and *Air Quality Data* files. These files may contain additional data before and/or after the start and end dates, but must contain data for the entire period between the specified start and end dates.
Adjust for Daylight Saving Time (DST)	Specified using the ***DSTAdjust*** keyword in the *Control* file. If this parameter is set to "YES", then the Air Quality Data file will be adjusted for DST in the summer; if it is set to "NO", no adjustment is made. This keyword should be set to "YES" if the Air Quality Data file is based on Standard Time yet the activity data are based on DST.	Changing this setting means that the *Air Quality Data* file is based on DST (it typically is in Standard Time) or that the activity data are based on Standard Time (the supplied CHAD data are based on DST). Regardless of this setting, the output (hourly exposure and dose) for all simulated days will contain exactly 24 hours, and all input activity diaries must contain exactly 24 hours.
Model worker commuting	Specified using the ***Commuting*** keyword in the *Control* file. If this keyword is set to "YES", commuting to work is allowed and the user must provide a *Commuting Flow* file in the appropriate format and employment data must be specified in the *Employment Probabilities* file; if it is set to "NO", all workers are assumed to work at home and the user is not required to provide a *Commuting Flow* file. *The Commuting Flow* file accompanying APEX contains commuting flows between all census tracts from the 2000 Census. These commuting data are sufficient for all applications in which the sectors are defined as census tracts.	If the user chooses to define sectors as something other census tracts, a new *Commuting Flow* file (in addition to a number of other input files) must be created corresponding to the new sectors.
Air quality rollback adjustment (for estimating exposure in hypothetical control scenarios)	Specified using the ***Rollback*** keyword in the *Control* file. If this keyword is set to "YES", the user must specify appropriate values for the ***RBTarget, RBBackgnd***, and ***RBMax*** keywords in the Control file; if it is set to "NO", values are not required for these keywords (and any present will be ignored).	If the ***Rollback*** keyword is changed to "YES" in the *Control* file accompanying APEX, the ***RBTarget, RBBackgnd***, and ***RBMax*** keywords must be set to appropriate values.
Time resolution (length of APEX timestep)	Specified using the *TimestepsPerDay* keyword in the Control file. The timestep can be either smaller or larger than an hour. However if the timestep is larger than an hour, it must be an integer multiple of an hour. If it is smaller than an hour, there must be an integer number of timesteps in an hour. The default APEX timestep is one hour. If *TimestepsPerDay* is not set, then APEX uses the default.	The timestep dictates the required time resolution of the following air quality input. The time resolution of the *Air Quality Data* file must match that indicated by *TimestepsPerDay.*
STUDY AREA LOCATION		
Center of study area	Specified as the latitude and longitude of the center of the study area in decimal degrees using the ***Latitude*** and ***Longitude*** keywords in the *Control* file. The user must always define the appropriate study area center for an application.	If the study area is changed, the user must ensure that the following files contain appropriate data for the new location: *Population sector location* file (unless the included file is used), *Air district Location* file, *Meteorology Zone Location* file, *Meteorology Data* file, and *Air Quality Data* file.
Radius of study area	Specified as the distance (in km) from the center to the edge of the study area using the ***CityRadius*** keyword in the *Control* file. The user must always	If the study area is changed, the user must ensure that the following files contain appropriate data for the new location: *Population sector location* file

SETTING/OPTION	***How Option is Selected***	***Impact of Changing Default Setting on Other Input Files***
	define the appropriate study area radius for an application.	(unless the included file is used), *Air district Location* file, *Meteorology Zone Location* file, *Meteorology Data* file, and *Air Quality Data* file.
Restrict study area to selected counties	Specified using the ***CountyList*** keyword in the *Control* file. If the value of this keyword is set to "YES", the user must list the FIPS code (or other relevant portion of the sector ID if the supplied sector files are not used) for the counties to which the study area will be restricted using the ***County*** keyword in the *Control* file. The county IDs for all census tracts in the 2000 Census are included in the Population sector location file accompanying APEX, thus allowing the user to select counties in the Control file without making changes to the included Population sector location file.	None, normally. However, if the user does not use the included *Population sector location* file, they must ensure that the new *Population sector location* file provides the county ID for each sector as part of the sector ID in the appropriate format.
Restrict study area to selected census tracts	Specified using the ***TractList*** keyword in the *Control* file. If the value of this keyword is set to "YES", the user must list the sector (tract) ID for the tracts to which the study area will be restricted using the ***Tract*** keyword in the *Control* file. The sector IDs for all census tracts in the 2000 Census are included in the Population sector location file accompanying APEX.	
Locations of sectors	Specified as sector IDs and locations (latitude and longitude) in the *Population sector location* file. The *Population sector location* file accompanying APEX use the census tracts from the 2000 Census as sectors. This file also specifies the county associated with each sector (via the first five characters of the sector ID, which are the county FIPS codes in the supplied data), which allows the user to restrict the study area to selected counties. In most cases, the user will not need to change this setting as it provides sectors with the necessary population and commuting data for the entire United States.	Sectors identified in *Population sector location* file must match the sectors identified in *Population Data* files. If the user wishes to use census tracts from the 2000 Census, the *Population sector location* file accompanying APEX will be sufficient. All of the sectors used in the commuting file must be included in the *Population sector location* file and the *Population Data* files; if sectors other than 2000 Census tracts are used, the user must provide a *Commuting* file compatible with these sectors. In addition, if the user wants to restrict the study area to selected counties, the *Population sector location* file must include the county IDs associated with sector as part of the sector IDs in the proper format (as in the supplied file).
Locations of air districts	Specified in the *Air district Location* file. The user must always define the appropriate air districts for an application.	The locations of the air districts must be selected such that they can provide reasonable estimates of air quality for the sectors and study period included in the analysis. Data for each AQ monitor for each pollutant in the simulation must be provided in the Air Quality Data files (one for each pollutant).
Radius of air district	Using the ***AirRadius*** keyword in the *Control* file, the user can specify the maximum distance (in km) that a sector can be from the nearest air district to remain in the study. If all district centers are further than ***AirRadius*** from the sector center, the sector is removed from the study area and is not modeled. Users must always define an appropriate value for this radius based on their application.	The radius of the air districts must be selected such that they will include the sectors the user would like to include in the analysis.
Type of Air Quality Data	The keyword *ModelAQVar* specifies the type of air quality data to be used in the simulation. The air quality may be entered as raw values for each timestep in the simulation (the default, *ModelAQVar*=N) or as distributions for each hour (*ModelAQVar*=Y).	The value of *ModelAQVar* dictates the expected format of the *Air Quality Data* file. See Section 4.5 for details.
Location of meteorological data stations	Specified as zone IDs and locations (latitude and longitude) in the *Meteorology Zone Location* file. The user must always define the locations of meteorological stations for an application.	Data for each meteorological data station specified in the *Meteorology Zone Location* file must be provided in the *Meteorology Data* file.

SETTING/OPTION	*How Option is Selected*	*Impact of Changing Default Setting on Other Input Files*
Radius of meteorological station coverage	Using the ***ZoneRadius*** keyword in the *Control* file, the user can specify the maximum distance (in km) from a sector to the nearest meteorological station. If all zone centers are further than ***ZoneRadius*** from the sector center, the sector is removed from the study area and is not modeled. Users must define an appropriate value for this radius based on their application.	The radius of the zones must be selected such that they will include the sectors the user would like to include in the analysis.
POLLUTANTS		
Number of pollutants	The number of different pollutants to be modeled must be specified using the ***#Pollutants*** keyword	
Pollutant Names	The user must specify each pollutant with the keyword ***Pollutant***. The pollutant name may contain only alphanumeric characters and the underscore ("_") character, as it is used to generate filenames.	Must be followed in the *Control* file by the pollutant-specific parameters and output table levels.
Model dose for pollutant	Specified using the ***DoDose*** keyword in the *Control* file. Pollutant-specific. If this keyword is set to "YES", APEX will calculate dose for the pollutant; if it is set to "NO", the dose calculations will be suppressed.	If ***DoDose*** is set to "YES" and CO is being modeled the user must specify the correct values for the ***Altitude, COHBFact*** keywords in the *Control* file.
PROFILES		
Number of profiles	Set to an integer using the ***#Profiles*** keyword in the *Control* file. Users must define an appropriate value for this keyword based on their application.	None.
Modeled populations	Specified in the *Control* file following the specification of the file names. The user must provide a population file for each population to be modeled and indicate the gender and race associated with the file. All gender/race combinations without specified population files are assumed to have zero populations. Users can select from the sets of available *Population Data* files accompanying APEX (i.e., the national population files or the files specific to the Houston example applications), or generate their own.	If the user wishes to model a subpopulation, the user must supply alternative *Population Data* files with the appropriate counts.
Profile function options	Specified in the *Profile Functions* file. The user must develop data relevant to a particular application prior to performing an APEX simulation.	None.
Employment status	Specified in the *Employment Probability* file for implementation of commuting. The file accompanying APEX should be sufficient for all applications where sectors are defined as census tracts.	None.
Minimum and maximum ages for simulated profiles	Specified using the ***AgeMin*** and ***AgeMax*** keywords in the Control file.	None.
Modeled age groups	Specified in the *Population Data* files. The files that accompany APEX define the age groups as single years up to 99, and are sufficient for all applications where sectors are defined as census tracts.	None.
Size of age window	The ***AgeCutPct*** and ***Age2Probab*** keywords in the *Control* file are used to specify the window around the assigned age of a profile from which activity data can be selected.	None.
Probabilities for selecting diaries with missing characteristics	Using the ***MissGender, MissEmpl,*** and ***MissAge*** keywords in the *Control* file, the user can specify the probability that activity diary data with missing gender, employment status, or age will selected.	None.

SETTING/OPTION	*How Option is Selected*	*Impact of Changing Default Setting on Other Input Files*
Type of diary assembly	Determined by the ***LongitDiary*** keyword. If YES, longitudinal dairy assembly will be performed based on the statistic in the *Diary Statistics* file. If NO, APEX will randomly select a new activity diary for each day in the simulation.	If ***LongitDiary*** is YES, then the *Diary Statistics* file must be designated in the *Control* file, and the ***DiaryD*** and ***DiaryAutoC*** keywords must be set.
Physiological parameters for the simulated population	Specified in the *Physiological Parameters* file. The default values in this file are suitable for most APEX applications.	None.
Activity-specific energy expenditures for the simulated population	Specified in the *MET Mapping* and *MET Distribution* input files. The default values in these files are suitable for most APEX applications.	None.
Modeling of disease prevalence	Determined by the ***Disease*** keyword. If ***Disease*** is given a value (a string of maximum length 12 characters containing the condition name, spaces allowed) in the input file, APEX will then use data in the *Prevalence* file to assign a YES/NO value to the physiological profile variable **Ill**, and produce output tables for the subpopulation of modeled persons with **Ill**=YES.	If ***Disease*** is given a value (a string of maximum length 12 characters containing the condition name, spaces allowed) in the input file, then APEX requires that a *Prevalence* file be designated as well.
MICROENVIRONMENTS		
Maximum number of microenvironments	Set to an integer using the ***#Micro*** keyword in the *Control* file; must not exceed 127.	Number of APEX microenvironments in the *Microenvironment Mapping* and *Microenvironment Descriptions* files must not exceed the specified value in the *Control* file.
Microenvironment definitions	Specified in the *Microenvironment Descriptions* file. The user must develop data relevant to a particular application prior to performing an APEX simulation.	Each location referenced in the activity database (e.g., CHAD) must be mapped to one of the microenvironments specified in the *Microenvironment Descriptions* file using the *Microenvironment Mapping* file. The user may choose to define custom microenvironmental parameter definitions that depend on conditional variables. If so, these variables must be defined on the *Profile Functions* file.
OUTPUTS		
Produce hourly outputs	Specified using the ***HourlyOut*** keyword in the *Control* file. If this keyword is set to "YES", the hourly output file is created; if it is set to "NO", the file is not created. The variables to be written are listed using the keyword *HOURLYLIST*.	None.
Produce daily outputs	Specified using the ***DailyOut*** keyword in the *Control* file. If this keyword is set to "YES", the hourly output file is created; if it is set to "NO", the file is not created. The variables to be written are listed using the keyword *DAILYLIST*.	None.
Produce microenvironmental output	Specified using the ***MSumOut*** and ***MResOut*** keywords in the *Control* file. If these keywords are set to "YES", the *Microenvironmental Summary* and/or *Microenvironmental Results* output files are created; if they set to "NO", these files are not created.	None.
Produce event output	Specified using the ***EventsOut*** keyword in the *Control* file. If this keyword is set to "YES", the events output file is created; if it is set to "NO", this file is not created.	None.

3.4 Running APEX in Batch Mode

The compiled code of the APEX model is stored as an executable file. In general, running the model requires calling this executable and specifying a valid APEX *Simulation Control* file. The *Simulation Control* file (which we also refer to as the *Control* file) is a text file that acts as a "master" APEX input file. It contains the locations of all the required APEX input and output files, as well as the model settings, and is described in detail in the next Chapter.

There are several methods of invoking the APEX program. These include:

- T*yping the path and file name of the APEX executable at the prompt in a DOS window, followed by the path and name of the Control file*. For example:

  C:\APEX4\apex4.exe C:\APEX4\Input\SimControl.txt

  If the *Control* file name is omitted from this command, APEX will prompt the user for the "Unit(10)" file, at which time the user would input the location (path) and name of the *Control* file. APEX calls the *Control* file "Unit(10)" internally, which is the indication given at the prompt. If any other unit number is requested, then that means that one of the other input files (which are designated in the *Control* file) cannot be found (see Table 3-1 to identify which file), and the user should consult the instructions on input files in Chapter 4 of this guide.

- *Double-clicking on the APEX executable in Explorer*. APEX will prompt the user for the "Unit(10)" file, at which time the user would input the location and name of the *Control* file.

- *Selecting "Run" from the Windows "Start" menu and entering the path and filename for the .exe file and the Control file.* Once again, if the *Control* file name is omitted from this command, APEX will prompt the user.

- *Batch mode, described below.*

The preferred way to run APEX is in batch mode, meaning that the model's executable (.exe) and *Control* files are specified in a single user-created text file (referred to as a "batch" file) that is submitted to the operating system for job execution. With this method, multiple APEX runs may be performed at once. To run APEX in batch mode, the user must complete the following steps.

1. Create the APEX batch file

To create an APEX batch file, open a new file in a text editor. On each line of this file, enter the file path and name of the APEX executable followed by a space and the file path and name of a unique *Control* file. An example is given in Exhibit 4-1. The commands shown in Exhibit 4-1 perform five APEX runs in series. In this manner, multiple runs using different model settings can be started by running the batch file. Note that each of the *Control* files used should contain unique names for the model output files to avoid overwriting the output from the previous run. See Chapter 4 for information on designating output file names in the *Control* file. After entering the information, save the file. The file can be named anything, provided it ends with the extension ".bat" (e.g., APEXbatch.bat).

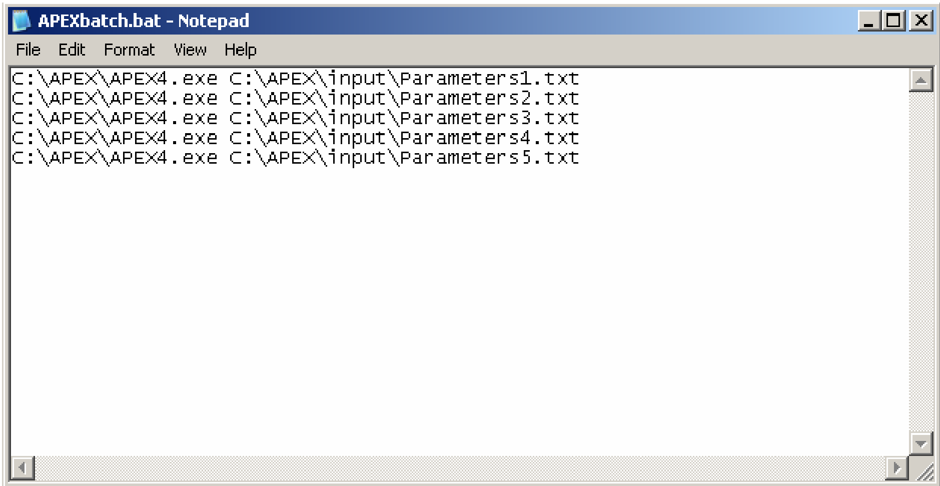

Exhibit 4-1. Starting a Number of APEX Jobs Using a Batch File

2. Run the APEX batch file

APEX can be run using the batch file in any of the following ways.

- Opening a DOS window and typing the batch file name (and path, if necessary)
- Double-clicking on the batch file in Explorer
- Selecting "Run" from the Windows Start menu and entering the file path and name of the batch file
- Creating a shortcut to the batch file on the desktop by selecting the batch file in Explorer, right-clicking the mouse, and selecting "Create Shortcut" from the menu. A shortcut file will be created and this file can be dragged onto the desktop and optionally renamed. To run APEX, double-click on this shortcut.

Except for the first method (a DOS window is already open), when APEX runs, a DOS window appears. As the model run starts and then progresses, normal status messages will be printed to the screen (see Exhibit 1-2), in addition to any error or warning messages that may arise from incomplete or incorrect model set-ups.

After the initialization of the run, APEX will begin progressing through the simulated profiles. When the model run ends, APEX will stop, as shown in Exhibit 1-3.

```
Simulation start date =    19950101      728294
Simulation end date   =    19951231      728658
Finished ReadPopulation
Finished ReadEmployment
Finished GenerateProfiles
Finished GeneratePhysiology
Reading activity diary #        1000       36141
Reading activity diary #        2000       74638
Reading activity diary #        3000      113892
Reading activity diary #        4000      159710
Reading activity diary #        5000      207746
Reading activity diary #        6000      254202
Reading activity diary #        7000      296423
Reading activity diary #        8000      331133
Reading activity diary #        9000      365358
Reading activity diary #       10000      399993
Reading activity diary #       11000      435016
Reading activity diary #       12000      470612
Reading activity diary #       13000      505427
Reading activity diary #       14000      540340
Reading activity diary #       15000      575812
Reading activity diary #       16000      614773
Diaries Discarded=        6793
Pool sizes=       16175
Finished output for profile #           1   of           100
```

Exhibit 1-2. Screenshot of the Start of an APEX Run

```
 Finished output for profile #          96  of           100
 Finished output for profile #          97  of           100
 Finished output for profile #          98  of           100
 Finished output for profile #          99  of           100
 Finished output for profile #         100  of           100
Finished APEX model run
Press any key to continue_
```

Exhibit 1-3. Screenshot of Successful Completion of an APEX Run

Even if an APEX simulation runs to completion (i.e., as shown in Exhibit 1-3), the user should examine the APEX *Log* output file to confirm that the model behaved as expected. The *Log* file contains information on the model settings, input parameter values, and input and output file names. The file also contains a great deal of detailed information about the model run, including (but not limited to) summaries of (1) the modeled profiles, (2) the final study area (including the final sectors, air quality districts, and meteorology zones), (3) the simulated microenvironments. The *Log* file (which is discussed in Section 5.1) will also contain listing of any warning or error messages that resulted from the run.

CHAPTER 4. APEX INPUT FILES

This chapter provides the details necessary for creating and modifying the APEX input files. The first section describes the general format and properties that pertain to all of the APEX input files, while the remaining sections cover each input file in detail.

4.1 Input File Formats

The APEX input files and their descriptions are given in Table 4-1. Some of the input files are not required if certain features of the model are turned off. For example, the *Diary Statistics* file is not needed if longitudinal diary assembly is not being used, and the *Commuting Flow* file not needed if commuting is not considered. These are noted in Table 4-1. All input files are ASCII text files that can be edited using a text editor. Each input line of these files is categorized into one of four types:

1. Keyword (or variable or parameter) line: Keywords are used in the *Simulation Control* file to indicate to APEX where the input files are located and what values should be assigned to certain variables. A keyword line always contains an "=" sign. The part of the line to the left of "=" is called the "keyword" and the part to the right is called the "value." The keyword must start with a letter and must match the spelling sought by the program code, after which the keyword may contain other letters, blanks, or commas. APEX uses the keyword to locate and set the input values. The values may be character, logical, or numeric values, or file names.
2. Numeric line: Any line beginning with a digit (0-9) is recognized as a numerical data line by APEX. Non-digits may appear later in a numeric line.
3. Character line: A line that begins with a character but does not contain an "=" sign is recognized as a character data line.
4. Comment line: Any blank lines and any lines beginning with "!" generally are regarded as comment lines by APEX and used only by the user to help document the input file data. However, comment lines should not be inserted in the middle of a block of data. That is, if the computer code is expecting to read a long series of numbers without a break, then comments may break the flow.

The keywords and input values are not case sensitive, except as noted. Also, each line on an input file is processed independently by APEX. Continuation of data values across multiple lines is not permitted unless specifically noted for a particular file. APEX uses "list" (or "free") format for all input values. This means that the values or data do not have to be fixed in specific positions on an input line. Multiple items on an input line can be separated by either a blank or comma. The various site names and similar inputs should not contain internal blanks, as these will be interpreted as delimiters between input fields. This does not apply to keyword lines, as those lines have only two fields (separated by the "=" sign), so either or both sides may contain internal blanks.

Table 4-1. APEX Input File Descriptions

Input File	Description
Simulation Control File	Specifies the overall settings (or parameters) for an APEX simulation (i.e., input file names, population data file names, output file names, job parameter settings, and output table levels).
Population Data Files	Contains information on the population (by age group) in each study sector. Each race/gender combination has its own file.
Employment Probability File	Contains employment probabilities by age group, gender, and study sector.
Commuting Flow File	Provides probabilities of a worker commuting to various destination census tracts from any given home tract. This file is only required when worker commuting is modeled (***Commuting*** =Y).
Population Sector Location File	Provides the IDs and locations (in degrees latitude and longitude) of sectors (e.g., census tracts). The file is used along with the user-defined ***CityRadius*** and other data to select the sectors within the modeled area.
Air District Location File	Provides the site IDs and locations (degrees latitude and longitude) of air quality monitoring or modeling locations. The file is used along with the user-defined ***AirRadius*** to define the geographical area covered by the air quality data. The air quality data from a monitoring or modeling location are used for the sectors (e.g., census tracts) within its covered area. Start and end dates indicate the dates during which the data for a particular location are valid.
Meteorology Zone Location File	Provides the site IDs and locations (degrees latitude and longitude) of the meteorological stations. The file is used along with the user-defined ***ZoneRadius*** to determine the area covered by the meteorological data. Start and end dates indicate the dates during which the data for a particular location are valid.
Meteorology Data File	May contain temperature, wind, humidity, and precipitation data for the meteorological stations and dates indicated in the *Meteorology Zone Location* file. These data can be used to determine window positions, group activity pattern pools, and microenvironmental parameters in APEX.
Air Quality Data File	Provides the air quality data for the modeled pollutants for each air monitoring/modeling location listed in the *Air District Location* file. The required time resolution of the air quality data for each day depends on the *Control* file setting *TimestepsPerDay*. Each file is pollutant specific, so there is the same number of input files as pollutants in the simulation. An optional type of air quality data may be used that includes distributions for hourly air quality values, see Section 4.5 for details.
MET Mapping File	Maps each activity codes present in the *Diary Events* file to an APEX MET distribution. (A MET value is a dimensionless ratio of the activity-dependent energy expenditure rate to the basal or resting metabolic rate). The MET distributions are defined by number in the *MET Distribution* File.
MET Distribution File	Provides distribution types and parameters for calculating the metabolic (MET) value for each distribution number in the *MET Mapping* file. A MET value is a dimensionless ratio of the activity-dependent energy expenditure rate to the basal or resting energy expenditure (metabolic) rate.
Physiological Parameters File	Contains tables of age- and gender-specific physiological parameters.

Input File	**Description**
Ventilation File	This file contains regression parameters used to estimate total ventilation VE from MET.
Microenvironment Mapping File	Provides the mapping from activity location codes in the *Diary Events* file (e.g., from CHAD) to user-defined microenvironments in the *Microenvironment Descriptions* file.
Diary Questionnaire (DiaryQuest) File	Provides personal and other information (e.g., day type, gender, age, race, occupation) relating to each 24 hour activity record from the original activity database (e.g., CHAD).
Diary Events File	Provides the 24 hour event descriptions (i.e., start time, duration, activity, and location) for all the diary days in the original activity database (e.g., CHAD). This file contains the same list of diary IDs as the *Diary Questionnaire* file, in the same order.
Diary Statistics File	Contains the value of the key statistic for all CHAD activity diaries. These data are used in the longitudinal diary assembly algorithm. Statistics files are included with APEX for outdoor time and time spent in vehicles. Users could construct other statistics files from CHAD. This file is not required if longitudinal assembly is not being performed (***LongitDiary*** = NO).
Profile Functions (Distributions) File	Contains user-defined functions for several model variables, which in turn can be used by the model for a variety of purposes, including calculating microenvironmental concentrations.
Microenvironment Descriptions File	Contains the definitions of the microenvironments and the microenvironment parameters used to determine the exposure concentrations in microenvironments.
Prevalence File	Contains prevalence rates (probabilities) for disease (or any other condition) for different age/gender cohorts. This file is not required if the *Control* file variable ***Disease*** is not set.

The following sections discuss the details of APEX input files and provide several examples. Note that these example files in this and the next chapter are provided for illustration only. These are provided for the purpose of highlighting various aspects and options of APEX. While some of these examples are from the input files provided with the APEX Version 4 release, some of them have been changed to demonstrate specific aspects and options of APEX. In addition, most of these examples are only portions of the necessary input files. Thus, these example files will not work as an actual set of input files. Users are encouraged to view the example input files (which can be downloaded separately) for a complete set of input files.

4.2 Simulation Control File

The *Simulation Control* file (which we also refer to as the *Control* file) is APEX's master simulation file. The *Simulation Control* file names input and output files, sets model parameters, and controls formats of output files. APEX only processes keyword lines in this file. Any other types of input lines are ignored. However, the very first line of the file (even if it is a comment beginning with !) is saved to be used as part of the header that is written to each output file for audit trail purposes. Therefore, it is helpful for this line to include information that describes or identifies the simulation.

When creating the *Control* file, the following rules should be used:

- The very first line of the file should identify the specific simulation (up to 224 characters in length);
- Keywords (or parameter or variable names) are placed to the left of the equal sign in a keyword line;
- Parameter values are to the right of the equal sign;
- Lines may appear in any order after the first line, with the following exceptions:
  - Lines using the ***County*** keyword, which must immediately follow the line with the ***CountyList*** keyword;
  - Lines using the ***Tract*** keyword, which must immediately follow the line with the ***TractList*** keyword;
  - Lines using pollutant-specific parameters or table levels, which must immediately follow the line with their corresponding ***Pollutant*** keyword.
- Lines may be omitted if defaults are allowed and are acceptable;
- Only one equal sign is allowed per keyword line;
- Anything after an exclamation mark in a line is treated as a comment and ignored; and
- Any unexpected line without an equal sign treated as a comment and is ignored.

It is useful to keep a copy of the *Control* file associated with each simulation to provide a record of the input and output files and model settings associated with the simulation and to make it easier to run the model again based on different input data.

We describe the control file in terms of four sections of the file: input files, output files, pollutant parameters (including output table levels), and job parameters. Organizing the *Control* file in this manner is not required. The details of each section are discussed below.

4.2.1 Input and Output File List Sections of the Simulation Control File

In the Input Files section of the *Control* file (Exhibit 4-1), the user needs to specify the names and path names of all of the input files. The details on the content and format of these input files are provided in the subsequent sections of this chapter.

The keywords for these files were given in Table 3-1. (The keyword may be longer than those listed, as long as the listed keyword is contained within the text). The keyword ***FILE*** must appear (with a blank space before it) right after each of the file keywords and before the "=". If any of these files are not found at the specified locations, then APEX will print an error listing the file that is missing.

The *Air Quality Data* files are the only input files that are pollutant-specific, and thus there is one file for each pollutant modeled. Each ***Air Quality file*** keyword must be followed by a comma and the name of its corresponding pollutant (the pollutant names must match the names given by the ***Pollutant*** keyword in the simulation control file; see Section 4.2.2). Exhibit 4-1 provides an example of designating *Air Quality Data* files for a two-pollutant scenario (CO and ozone).

The example in Exhibit 4-1 has 10 population data files. The number of population files could change, depending on how the user classifies the population. For example, the user could provide two population files, for all females and all males.

For the population input files, the keywords ***Pop*** and ***File*** must appear at the beginning of the keyword part of the keyword input line in the *Control File*, followed by a comma and ***Gender*** and another comma and ***Race***. ***Gender*** must be either male or female and it can be shortened to M or F. If the population files provided with APEX are to be used, the ***Race*** must be White, Black, Asian, NatAm, or Other.. If the user provides the population files, ***Race*** could be different, however, the race name must have 5 or more characters, with the first 5 characters of each race being unique. For example, if one file each is given for all males and all females, ***Race*** could be specified as *AllRaces*. It is necessary for ***Race*** to match the designation in the header of the population files, or an error will result. Further information on population files is given in Section 4.8.

It is not necessary to specify all genders and race combinations for APEX to run. However, the model assumes that any missing gender/race combinations have zero population. A warning message is returned if one gender for a race is present but the other is missing.

In the Output File section of the *Control* file (Exhibit 4-2), the user needs to specify the keywords (Table 3-1), names, and paths for the output files. If the user turns off the hourly file creation, event file creation, or microenvironmental summary file creation, the corresponding output files will not be generated, and file names do not need to be specified. The Microenvironmental Summary, Microenvironmental Results, and Tables files are pollutant-specific, and one of each of these files will be created for each pollutant. However, only one filename for each type has to be defined in the Control file – output filenames for each pollutant are constructed by appending the pollutant name (as defined using the *Control* file ***Pollutant*** keyword) to the end of the filename base. The details of the output files are further explained in Chapter 5.

```
! INPUT FILES
 Zones file                    =   C:\APEX\APEX\METsites.txt
 Air Quality file, ozone       =   C:\APEX\AirQuality_ozone.txt
 Air Quality file, co          =   C:\APEX\AirQuality_co.txt
 Districts file                =   C:\APEX\AQdistricts.txt
 Meteorology file              =   C:\APEX\METdata_h.txt
 Functions file                =   C:\APEX\ProfileFunctions.txt
 Microenvironment file         =   C:\APEX\MicroDescriptions.txt
 MEMap file                    =   C:\APEX\ME_Mapping.txt
 DiaryEvent file               =   C:\APEX\CHADEvents.txt
 DiaryQuest file               =   C:\APEX\CHADQuest.txt
 METSMap  file                 =   C:\APEX\CHADMap.txt
 METS Distribution file        =   C:\APEX\MetsDists.txt
 DiaryStat file                =   C:\APEX\CHADSTATSoutdoor.txt
 Physiology file               =   C:\APEX\Physiology.txt
 Ventilation file              =   C:\APEX\Ventilation.txt
 Prevalence file               =   C:\APEX\Asthma.txt
 !
 ! POPULATION INPUT FILES
 Pop file, Female, Asian       =   C:\APEX\pop_fa.txt
 Pop file, Female, Black       =   C:\APEX\pop_fb.txt
 Pop file, Female, Natam       =   C:\APEX\pop_fn.txt
 Pop file, Female, Other       =   C:\APEX\pop_fo.txt
 Pop file, Female, White       =   C:\APEX\pop_fw.txt
 Pop file, Male,   Asian       =   C:\APEX\pop_ma.txt
 Pop file, Male,   Black       =   C:\APEX\pop_mb.txt
 Pop file, Male,   NatAm       =   C:\APEX\pop_mn.txt
 Pop file, Male,   Other       =   C:\APEX\pop_mo.txt
 Pop file, Male,   White       =   C:\APEX\pop_mw.txt
 Sectors file                  =   C:\APEX\pop_geo.txt
 Employment file               =   C:\APEX\Employment.txt
 Commuting file                =   C:\APEX\Commuting2000.txt
```

Exhibit 4-1. Input Files Section of Simulation Control File

```
! OUTPUT FILES
  log file                     =   C:\APEX\log.txt
  hourly file                  =   C:\APEX\hours.txt
  daily file                   =   C:\APEX\days.txt
  events file                  =   C:\APEX\events.txt
  persons file                 =   C:\APEX\psum.txt
  microsum file                =   C:\APEX\msum.txt
  microres file                =   C:\APEX\mres.txt
  tables file                  =   C:\APEX\tables.txt
  site file                    =   C:\APEX\sites.txt
```

Exhibit 4-2. Output Files Section of Simulation Control File

4.2.2 Pollutant Parameters Section of the Simulation Control File

The *Control* file variables (keywords) ***Pollutant***, ***DoDose***, ***InputUnits***, ***OutputUnits***, ***PPMFactor***, and ***#Sources***, are pollutant-specific. These parameters are described in Table 4-2.

#Pollutants must be equal to the number of different pollutants being modeled. It must precede any ***Pollutant*** keywords. The ***Pollutant*** keyword is used to 1) assign a name to each pollutant being modeled and 2) designate the start of the definition of the pollutant-specific variables. Thus, the ***Pollutant*** keyword must immediately precede the definition of the variables for a given pollutant. The pollutant name may be up to 40 alphanumeric characters long, and may also contain an underscore ("_") character. When modeling PM, each discrete size of PM must be modeled as a separate pollutant. All PM pollutants must start with the characters "PM." The ***Size*** and ***Density*** parameters must be defined for these pollutants.

Table 4-2. Pollutant Job Parameters

Keyword	Type (length)	Description
#Pollutants	Integer	The number of pollutants in the simulation. Any number of pollutants may be modeled - the maximum is limited only by the available system memory.
Pollutant	Char(40)	Pollutant name. There must be one ***Pollutant*** statement for each pollutant modeled, which must be immediately followed by the other pollutant-specific job parameters and table levels. If the pollutant is a particle, then the pollutant name must start with the characters "PM".
InputUnits	Char(40)	Pollutant concentration units used for the input data for the pollutant (ppm or $\mu g/m^3$).
OutputUnits	Char(40)	Pollutant concentration units used for the output data for the pollutant (ppm or $\mu g/m^3$).
#Sources	Integer	Largest number of sources in any one microenvironment for the pollutant Any number of sources may be modeled - the maximum is limited only by the available system memory.
PPMFactor	Real	Units conversion factor, the number of $\mu g/m^3$ that equate to 1 ppm. For CO, ppmfact = 1,145 (i.e., 1 ppm = 1,145 ug/m^3). It is used when source strengths are expressed in micrograms per hour, but concentrations are in parts per million (ppm), and when ***InUnits*** and ***OutUnits*** are in different units.
DoDose	Char(1)	Y = perform dose calculations, N = don't perform calculations. If this flag is NO, the dose calculations will be turned off. This saves some job execution time if the user does not need dose calculation.
Size	Real	Aerodynamic diameter (particle size) in micrometers for a particle pollutant. This parameter is not required for gaseous pollutants.
Density	Real	Density (in g/cm^3) of a particle pollutant

In the Pollutant Parameters section, the user also specifies the levels of each of the parameters used in the creation of the output summary tables for each pollutant. These specification parameters are ***Percentiles, TimeExp, DM1HExp, DM8HExp, TSExp, DMTSExp, DAvgExp, SAvgExp, TimeDose, DM1HDose, DM8HDose, TSDose, DMTSDose, DAvgDose, and SAvgDose***. The table specifications for each pollutant must come after the corresponding ***Pollutant*** keyword. Each parameter is identified by a single keyword, and the values are a list of numbers ordered from smallest to largest and separated by commas. All the values are read as real numbers, although the decimal points are optional if the values happen to be integers. Items in each list must be separated by commas. Except for the ***Percentiles***, all of these parameters are used to bin exposures or doses into categories in order to create output tables. Note that there is always one more bin than there are number of values in the list, since the first bin is less than the first value in the list and the last bin is greater than or equal to the last number in the list. The specific meanings of the parameters are explained in Table 4-3. Note that these parameters, with the exception of ***Percentiles,*** are optional; if they are omitted, then the corresponding table is simply not written in the output file. See Chapter 5 for more information on the APEX output tables.

Table 4-3. Output Parameter Levels in the Output Summary Table

Table Parameter	Keyword	Data Type	Description
Percentiles	***PERCENTILES***	Real	This parameter specifies the levels of percentiles of the exposed population for exposure or dose in APEX output files. Values can include up to one digit beyond the decimal point (e.g. the 99.5 or 99.9 percentile).
Exposure Cut points	***TIMEEXP***	Real	This parameter specifies the exposure cut points for summing time spent at various exposure levels. The time is expressed in minutes and is summed across all profiles. ***TimeExp*** is used in two tables. (Exposure Tables Type 1 and 2; see discussion of *Tables* file in Chapter 5)
Daily Max 1-Hour Exposure Cut points	***DM1HEXP***	Real	This parameter specifies the daily maximum 1-hour exposure cut-points for binning all the person-days in the simulation period. (Note: 1-hour tables are not generated with the APEX timestep is greater than one hour.)
Daily Max 8-Hour Exposure Cut points	***DM8HEXP***	Real	This parameter specifies daily maximum 8-hour average exposure cut-points for binning all the person days in the simulation period. It is similar to ***DM1HExp*** except for the longer averaging time. (Note: 8-hour tables are not generated with the APEX timestep is greater than one hour.)
Daily Max Timestep Exposure Cut points	***DMTSEXP***	Real	This parameter specifies daily maximum timestep exposure cut points for binning all the person days in the simulation period. It is similar to DM1HExp except that that the time period considered is a timestep rather than an hour. (Note: If using the default timestep of one hour, then only the hour tables are generated - the timestep tables are not.)
Timestep Exposure Cut points	***TSEXP***	Real	This parameter timestep exposure cutpoints for counting multiple exceedances of timestep levels over the simulation (Exposure table type #9; see discussion of *Tables* file in Chapter 5)
Daily Average Exposure Cut points	***DAVGEXP***	Real	This parameter specifies daily average exposure cut-points for binning all the person-days in the simulation period.
Simulation Average Exposure Cut points	***SAVGEXP***	Real	This parameter specifies cut-points for average exposure over the simulation period. The cut points are used to bin all simulated persons created in a run.
Daily Max 1-Hour Dose Cut points	***DM1HDOSE***	Real	This parameter specifies cut points in %COHb for Daily Maximum 1-Hour Dose. The cut points were used to bin all the person-days in the simulation period.

Table Parameter	Keyword	Data Type	Description
Daily Max 8-Hour Dose Cut points	***DM8HDOSE***	Real	This parameter specifies cut points in %COHb for Daily Maximum 8-Hour Dose. The cut points were used to bin all the person-days in the simulation period..
Daily Max Timestep Exposure Cut points	***DMTSEXP***	Real	This parameter specifies daily maximum timestep dose cut points for binning all the person days in the simulation period. It is similar to DM1HDose except that that the time period considered is a timestep rather than an hour. (Note: If using the default timestep of one hour, then only the hour tables are generated - the timestep tables are not.)
Timestep Exposure Cut points	***TSEXP***	Real	This parameter timestep dose cutpoints for counting multiple exceedances of timestep levels over the simulation (Dose table type #5; see discussion of *Tables* file in Chapter 5)
Daily Max End-of-hour Dose Cut points	***DMEHDOSE***	Real	This parameter specifies cut points in %COHb for Daily Maximum End-of-Hour Dose. The cut-points are used to bin all the person/days in the simulation period. Note that DMEHDose uses the instantaneous level at the end of each hour, whereas DM1HDose uses the time-averaged level over each hour. For CO, These two statistics usually track each other fairly closely. For other pollutants, the end-of-hour dose is just the dose on the last event of the hour.
Hourly End-of-hour Dose	***H_EHDOSE***	Real	Similar to DMEHDose, except that instead of using just the highest single end-of-hour dose on each day, it collects results for all 24 end-of-hour doses on each day. As with the other keywords, the values specified here refer to the cut points used for tabulating the dose results.
Daily Average Dose Cut points	***DAVGDOSE***	Real	This parameter specifies cut points in dose for the Daily Average Dose. The cut-points are used to bin all the person/days in the simulation period.
Simulation Average Dose Cut points	***SAVGDOSE***	Real	This parameter specifies cut points in dose for the Average Dose over the entire simulation. The cut-points are used to bin all the persons (or profiles) created in the APEX run.
Dose Cut points	***TIMEDOSE***	Real	This parameter specifies cut-points in dose for summing time spent at various dose levels. Apart from the statistic, the tables resemble the Time Exp tables.
Time Step Multiple Exceedance Cutpoints	***TSMULTI***	Real	This parameter lists the number of exceedances to use as cutpoints in Exposure table type #9 and Dose table type #5 (multiple exposure or dose exceedances of timestep values of the simulation; see discussion of *Tables* file in Chapter 5). For example, if the user may want to track the number of persons that have 1, 10, 50, and 100 exceedances of the levels indicated by TSExp and TSDose over the course of the simulation.

The following example *Control* file excerpt shows an example pollutant parameters section for a simulation of two pollutants: ozone and CO:

```
! POLLUTANT PARAMETERS
 #Pollutants = 2

 Pollutant   = Ozone
 DoDose      = NO
 InputUnits  = ppm
 OutputUnits = ppm
 PPMFactor   = 1.
 #Sources    = 0
 Percentiles  = 10, 25, 50, 75, 90, 95, 99
 Percentiles  = 10, 25, 50, 75, 90, 95, 99
 TimeExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08
 DM1HExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08
 DM8HExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08
 DAvgExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08
 SAvgExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08
 AlertThresh  = 0.16

 Pollutant   = CO
 DoDose      = YES
 InputUnits  = ppm
 OutputUnits = ppm
 PPMFactor   = 1145.0
 #Sources    = 1
 Percentiles  = 10, 25, 50, 75, 90, 95, 99
 TimeExp      = 2, 4, 6, 8, 10, 15, 20, 25, 30, 35, 40, 45, 50 , 60
 DM1HExp      = 5, 10, 20, 30, 40, 50, 75
 DM8HExp      = 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 20, 25
 DAvgExp      = 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, 20
 SAvgExp      = 0.5, 1, 1.25, 1.5, 1.75, 2, 2.5, 3, 4, 5, 6, 8, 10
 DM1HDose     = 0.5, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5, 2.75, 3.0
 DM8HDose     = 0.5, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5, 2.75, 3.0
 DMEHDose     = 0.5, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5, 2.75, 3.0
 H_EHDose     = 0.5, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5, 2.75, 3.0
 DAvgDose     = 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5, 2.75
 SAvgDose     = 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.4, 1.6, 1.8
 AlertThresh  = 100.
```

Exhibit 4-3. Pollutant Parameters Section of Simulation Control File

4.2.3 Job Parameter Settings Section of the Simulation Control File

In the Job Parameter Settings section of the *Control* file, the user can specify a number of different job parameters for APEX runs. Table 4-4 provides a description of the keyword, data type, and uses of these job parameters. As with Input and Output Files, the keyword is the part of the *Parameters* input line that is necessary to allow APEX to identify the parameter. Data type is either integer, real, or character. Each character variable has a specified length: input values longer than allowed will be truncated to this length, and values shorter than allowed are simply padded with blanks. In all cases in this section except ***County*** or ***Tract***, if the same keyword appears more than once, the last occurrence overwrites the others. Exhibit 4-4 shows an example of this section of the *Control* file.

When APEX runs, the values of all the job settings (including the default settings for parameters not explicitly set) will be printed to the *Log* file.

Table 4-4. Job Parameters in APEX Simulation Control File

Keyword	Type (length)	Description
Simulation Parameters		
#Profiles	Integer	Number of profiles to simulate.
RandomSeed	Integer	Seed>0 is user preset, Seed=0 gets seed from clock. If RandomSeed is changed between runs (using 0 for both runs or using two different non-zero numbers), two separate model runs of 100 profiles each time will be equivalent to one model run of 200 profiles. If RandomSeed is the same, the same 100 profiles will be generated over again. Control of the random number seeds is an important part of using APEX for sensitivity analysis. For example, when performing multiple runs with slightly different inputs, it may be convenient to sample the same set of profiles, activity diaries, and microenvironmental concentrations, in order to prevent stochastic differences between the runs from obscuring the differences due to the changed input.
End_Date	Integer	Simulation end date in YYYYMMDD format.
FirstProfile	Integer	First profile number to simulate. For example, this can be used for skipping to a particular person's profile when performing repeated runs using ***RandomSeed***.
Start_Date	Integer	Simulation start date in YYYYMMDD format (e.g., 19960704 for July 4, 1996).
TimeStepsPerDay	Integer	Number of timesteps in a day. This settings dictates the required time resolution of the air quality input data, as well at the resolution of calculated exposures and doses. The timestep can be either smaller or larger than an hour. However if the timestep is larger than an hour, it must be an integer multiple of an hour. If it is smaller than an hour, there must be an integer number of timesteps in an hour. Therefore, the following are allowable APEX timesteps: 1 hour, 2 hours, 6 hours, 5 minutes, 15 minutes. Examples of **unacceptable** timesteps are 14 minutes, 1.25 hours, etc. The size of the timestep is controlled by a new control file variable **TimeStepsPerDay**. Thus, to use an APEX timestep of 5 minutes, use **TimeStepsPerDay = 288** This parameter is optional. The default APEX timestep is one hour. If *TimestepsPerDay* is not set, then APEX uses the default.
Study Area Parameters		
Location	Char(40)	Study area location (for output labeling only; not used internally).
Latitude	Real	Latitude in decimal degrees for the center of the study area. Note that latitude south of the equator is negative.
Longitude	Real	Longitude in decimal degrees for the center of study area. Note that longitude west of the prime meridian is negative (e.g., in the United States).

Altitude	Real	Altitude of study area in feet. The altitude in feet is assumed constant for the study area. It is used in the Coburn-Forster-Kane (CFK) equation for determining blood COHb concentration. Only necessary for when simulating CO dose.
DSTadjust	Char(1)	Y = use Daylight Saving Time (DST) in summer, N = don't use DST. In areas that use DST, one day per year (in April) is only 23 hours long and another (in October) is 25 hours long. However, most air quality data sets are reported in Standard Time throughout the year. If ***DSTadjust*** is set to Y, the first and last days of summer time (using different rules before 1986) are determined, and the concentration from 2-3 a.m. on the short day is duplicated, while the concentration from 2-3 a.m. on the long day is deleted. Regardless of this setting, the output (hourly exposure and dose) for all simulated days will contain exactly 24 hours, and all input activity diaries must contain exactly 24 hours.
CityRadius	Real	Radius of study area in km. The population sectors (e.g., census tracts) with centers (or representative locations) within this radius will be automatically selected for modeling.
AirRadius	Real	Maximum representative radius (km) of air quality data collected at an air monitoring station or modeled at that location. Air quality data can be applied to the sectors within this radius.
ModelAQVar	Char(1)	Dictates the expected format of the *Air Quality Data* file. N (Default) = APEX expects raw AQ data for each timestep. Y=APEX expects AQ distributions for each hour of the simulation.
ZoneRadius	Real	Maximum representative radius (km) of temperature data collected at a weather station.
County	Char(5)	FIPS code for listed county (or other relevant portion of the sector ID if the supplied sector files are not used). ***County*** is used only if ***Countylist***=Y. Repeat this line for each additional county code.
CountyList	Char(1)	Y = the study area is composed of sectors in the listed counties (next variable) and within ***CityRadius;*** N = the study area is restricted to sectors within the specified ***CityRadius*** only or defined with the ***TractList***. The default value is N. (May be used in conjunction with ***TractList***; final study area is union of tracts and counties listed).
Tract	String	Sector ID for a listed sector (usually census tract). ***Tract*** is used only if ***Tractlist***=Y. Repeat this line for each additional sector to be used.
TractList	Char(1)	Y = the study area is composed of the sectors (usually census tracts) listed using the Tract keyword which are within ***CityRadius;*** N = the study area is restricted to sectors within the specified ***CityRadius*** only or defined with the ***CountyList***. The default value is N. (May be used in conjunction with ***CountyList***; final study area is union of tracts and counties listed).
Scenario	Char(40)	Scenario description (for output labeling only; not used internally).
Microenvironment Parameters		
#Micros	Integer	Number of microenvironments defined in the *Microenvironment Mapping* file and on the *Microenvironment Descriptions* file.
Commuting Parameters		

Commuting	Char(1)	Y = allow a simulated profile (or person) to commute to a work sector (or census tract), N = No commuting. If Y, a work sector (e.g., census tract) is randomly selected for each simulated profile based on the probabilities of work sectors a person may travel to from a home sector. If N, then workers are assumed to work in their home sector.
KeepLeavers	Char(1)	Y = the persons who commute outside of the study area will be modeled. While a commuter is at a workplace outside the study area, then the ambient concentration cannot be determined from any air district. Instead, it is assumed to be related to the average concentration overall air districts at the same point in time. Calling this average Cavg, the ambient concentration C for the person is: C=***LeaverMult****Cavg+***LeaverAdd***. If ***KeepLeavers*** = N, then these individuals are not modeled.
LeaverAdd	Real	Additive concentration term applied when working outside study area (only used if ***KeepLeavers*** = yes).
LeaverMult	Real	Multiplicative factor for city-wide average concentration, applied when working outside study area (only used if ***KeepLeavers*** = yes)
Diary Selection Parameters		
Age2Prob	Real	Diary probability factor for "shoulder" ages. This parameter allows an optional shoulder window of ages outside the primary age window. The shoulders have the same width in years as the main age window, so in the example under ***AgeCutPCT*** the shoulders are ages 20-29 and 51-60. The ***Age2Probab*** parameter operates like ***MissAge,*** by suppressing the selection probability in the shoulders. If ***Age2Probab*** = 0 then shoulder ages are never selected.
AgeCutPCT	Real	Width of main age window (%). Each simulated profile (person) is assigned a specific year of age. A window is created around this target age, of size equal to ***AgeCutPCT*** percent of the target age. If the target age is 40 and ***AgeCutPCT*** = 25, then the age window is ten years wide (25% of 40) and diaries for persons from 30 to 50 years of age inclusive are permitted to be selected. The age window is always at least 1 year wide.
AgeMax	Integer	Maximum age for simulated profiles (persons).
AgeMin	Integer	Minimum age for simulated profiles (persons).
MissAge	Real	Diary probability factor for missing age. Some of the supplied CHAD diaries are for persons of unknown age. This factor operates just like ***MissGender*** and ***MissEmpl*** to lower the selection probability for such diaries.
MissEmpl	Real	Diary probability factor for missing employment. Some of the supplied CHAD diaries are for persons of unknown employment status. Like ***MissGender,*** this factor lowers the selection probability for such diaries. If ***MissEmpl*** = 0, then such diaries will never be selected.

MissGender	Real	Diary probability factor for missing gender. Some of the supplied CHAD diaries are for persons of unknown gender. All profiles are assigned gender, however, and the CHAD diaries are selected from those of the same gender or from the unknowns. ***MissGender*** is used as a multiplicative factor to reduce the probability of selecting diaries of unknown gender. If ***MissGender***=0, then diaries with missing gender will never be selected. If ***MissGender***=1, then such diaries are equally likely to be selected as diaries of the correct gender. ***MissGender*** can also be set to values between zero and one. By setting ***MissGender*** to a non-zero value, you are essentially telling APEX it is OK to use a diary with missing gender for whatever profile you are generating. Allowing a small but nonzero value for ***MissGender*** expands the pool size without permitting very much chance of selecting a diary with missing gender.
Dose Parameters		
COHbFactor	Real	Convergence parameter for COHb algorithm. This is a safety factor that limits the permitted error in determining the solution to the CFK equation. Larger factors mean greater accuracy but slower evaluation. Numerical tests indicate that factors in the range of 2 - 3 are optimal for most purposes. Only necessary when simulating CO dose.
Location Parameters		
#OtherDistricts	Integer	Number of other districts to use in calculating the air quality for diary events with location=O ("Other") when ***SampleOtherLocs*** is used. (The probability of the person's home district being one of these districts is given by ***HomeProbab***.)
CustomWork	Comma-delimited list of CHAD activity codes	List of CHAD activity codes that will be assigned to location = W (Work).
HomeProbab	Real	Probability (0-1) of a person's home district being one of the districts used to calculate the air quality for diary events with location=O ("Other") when ***SampleOtherLocs*** is used.
SampleOtherLocs	Char(1)	If = Y, a random list of air districts will be selected for each person for calculating the air quality for diary events with location=O ("Other"). The number of districts selected for each person is given by ***#OtherDistricts***, and the probability of the person's home district being the list is given by ***HomeProbab***.
Rollback Parameters		
RbBack	Real	Rollback background concentration. Use same units as ***InputUnits.***
RbMax	Real	Rollback maximum concentration. Use same units as ***InputUnits.***
RbTarget	Real	Rollback target concentration. Use same units as ***InputUnits.***
Rollback	Char(1)	Y = use air quality rollback adjustments, N = don't use adjustments. Rollback adjusts the ambient air quality data before the exposure calculations occur. The purpose is to determine exposure in hypothetical scenarios where the ambient concentrations have been reduced by various controls.
Diagnostic Parameters		
DebugLevel	Integer	A value > 0 results in more information being written to the log file than for a value of zero.

Log File Switches		
LogDistrict	Char(1)	Y = the name and location of each of the air districts will be written to the *Log* file. Both a preliminary list (all the air districts in the *Air districts Locations* file that are within the study area and have data for the entire simulation period) and a final list (those required to simulate the final list of study sectors) are printed.
LogPopulation	Char(1)	Y = the following population information will be written to the *Log* file for each study area sector: The total population of the sector (TotalPop); the base population for the study (StudyPop), which will be smaller than TotalPop if only certain age ranges are being considered; the total population of workers in the sector (Workers); the sector population of workers who work inside the study area (WorkInside); and the final population (FinalPop) for the simulation, which may be smaller than StudyPop if the workers who leave the sector are excluded (if KeepLeavers=NO).
LogProfiles	Char(1)	Y = the following population information will be written to the Log file for each study area sector: The total population of the sector (TotalPop); the base population for the study (StudyPop), which will be smaller than TotalPop if only certain age ranges are modeled; the total number of workers in the modeled age range who live in the sector (Workers); the population of these workers who work inside the study area (WorkInside); and the final study population of the sector (FinalPop), which may be smaller than StudyPop if the commuters who leave the study area are not modeled (if KeepLeavers=NO).
LogSectors	Char(1)	Y = the name and location of each study sector will be written to the *Log* file. Both a preliminary list (all the sectors geographically within the study area) and a final list (those sectors within the study area having available air quality and temperature data) are printed.
LogTables	Char(1)	Y = all the tables that are written to the *Tables* file are also written to the *Log* file.
LogZones	Char(1)	Y = the name and location of each of the temperature zones will be written to the *Log* file. Both a preliminary list (all the air districts in the *Temperature Zone Locations* file that are within the study area and have data for the entire simulation period) and a final list (those required to simulate the final list of study sectors) are printed.
Output File Switches and Keywords		
CustomSample	Comma-separated list of integers	The profiles designated by ***CustomSample*** are written in addition to the profiles specified by the ***EventSample*** variable. If both ***EventsSample*** and ***CustomSample*** are set, then all the ***EventsSample*** events are written as before and any additional ***CustomSample*** events are written in the appropriate place in the numerical profile order. Writing of ***CustomSample*** events is dictated by the value of the ***EventsOut*** variable, so no events will be written if ***EventsOut***=N, even if a CustomSample is specified. If neither ***CustomSample*** nor ***EventSample*** is set, then events are written as dictated by the default ***EventSample*** value (if ***EventsOut*** = Y). If the user wishes to write only the ***CustomSample*** events, then *EventSample* should be set to 0.
DailyList	comma or space-separated strings	List of keywords indicating which variables are to be written to the *Daily* output file. See section 5.4 for details.

DailyOut	Char(1)	Y= the *Daily* output file containing values of daily parameters (exposures, doses, etc.) is created. Otherwise it is not written.
EventSample	Integer	Dictates which profiles have their event data written to the *Events* file. If ***EventSample***=K**,** then the data for every Kth profile is written.
EventsOut	Char(1)	Y = the output file containing the event-level model outputs for each simulated individuals is written. Otherwise, the file is not written.
HourlyList	comma or space-separated strings	List of keywords indicating which variables are to be written to the *Hourly* output file. See section 5.2 for details.
HourlyOut	Char(1)	Y= the *Hourly* output file containing values of hourly parameters (exposures, doses, etc.) is created. Otherwise it is not written.
MResHome	Char(1)	If =Y, then only values associated with "home" locations will be written to the *Microenvironmental Results* file. Otherwise, values will be written for "home", "work", and 'other" locations.
MResList	comma or space-separated strings	List of keywords indicating which variables are to be written to the *Microenvironmental Results* output file. See section 5.6 for details.
MResMicros	comma-separated list of integers	A comma-separated list of integers that indicate the microenvironments for which data will be written to the *Microenvironmental Results* file.
MResOut	Char(1)	Y = the *Microenvironmental Results* file will be created. Otherwise, the file is not written.
MSumOut	Char(1)	Y = the *Microenvironmental Summary* file will be created. Otherwise, the file is not written.
PsumList	comma or space-separated strings	List of keywords indicating which variables are to be written to the *Profile Summary* output file. See section 5.5 for details.
VaOutput	Char(1)	Y = the calculated alveolar ventilation rate will be written to the events file. Otherwise the values are not output.
TimeStepOut	Char(1)	Y= the *Timestep* file will be created. Otherwise, the file is not written. If the default timestep (1 hour) is used, then this file will not be written because it will be identical to the *Hourly* file.
TimeStepList	comma or space-separated strings	List of keywords indicating which variables are to be written to the *Timestep* output file. See Section 5.3for details.
Tables Parameters		
ActivePAI	Real	Threshold median daily PAI (MET) value for defining active persons. Simulated individuals having median PAI equal to or greater than this value over the simulation period will be included in the "active persons" population subgroup in the output exposure tables.
ChildMax	Integer	Maximum age for inclusion in the "child" and "active child" population subgroups in the output exposure tables.

ChildMin	Integer	Minimum age for inclusion in the "child" and "active child" population subgroups in the output exposure tables.
HeavyEVR1	Real	This parameter sets the threshold for equivalent ventilation rate defining one-hour heavy exertion. It is used in generating the APEX output tables for one-hour exposures under heavy exertion.
HeavyEVR8	Real	This parameter sets the threshold for equivalent ventilation rate defining eight-hour heavy exertion. It is used in generating the APEX output tables for eight-hour exposures under heavy exertion.
HeavyEVRTS	Real	This parameter sets the threshold for equivalent ventilation rate defining timestep-level heavy exertion. It is used in generating the APEX output tables for timestep exposures under heavy exertion. Thus, this value should be dependent on the length of timestep used.
ModEVR1	Real	This parameter sets the threshold for equivalent ventilation rate defining one-hour moderate exertion. It is used in generating the APEX output tables for one-hour exposures under moderate exertion.
ModEVR8	Real	This parameter sets the threshold for equivalent ventilation rate defining eight-hour moderate exertion. It is used in generating the APEX output tables for eight-hour exposures under moderate exertion.
ModEVRTS	Real	This parameter sets the threshold for equivalent ventilation rate defining timestep-level moderate exertion. It is used in generating the APEX output tables for timestep exposures under moderate exertion. Thus, this value should be dependent on the length of timestep used.
Longitudinal Diary Selection Parameters		
DiaryAutoC	Real	Lag-1 autocorrelation statistic for the longitudinal diary assembly algorithm. Provides a target for the autocorrelation in the key diary statistic.
DiaryD	Real	Provides a target D statistic for the longitudinal diary assembly algorithm. The D statistic reflects the relative importance of within person variance and between person variance in the key diary statistic.
LongitDiary	Char(1)	Y = APEX will use the longitudinal diary assembly algorithm to construct the activity diaries for the simulated persons, based on the statistics in the *DiaryStat* file. In this case, ***DiaryAutoC, DiaryD,*** and the name of the diary statistics file must all be designated in the *Control* file. If LongitDiary = N, then a new diary will be randomly selected each day (the default setting).
Disease Parameters		
Disease	Char(12)	Provides the name of a condition or disease. If set, then APEX expects the *Prevalence* file to be defined as well, and a subpopulation of persons with the condition will be modeled, resulting in exposure summary tables corresponding to the subpopulation. The tables will be labeled using this variable; spaces are allowed.

```
! ------- PARAMETER SETTINGS -------
! SIMULATION PARAMETERS
  #Profiles   = 40000
  RandomSeed  = 0
  Start_date  = 20040401
  End_date    = 20040930
!
! STUDY AREA PARAMETERS
  Location    = Description of Location of the Study Area
  Latitude    =  33.7629
  Longitude   = -84.4004
  Altitude    = 150.
  DSTadjust   = YES
  CityRadius  = 100.
  AirRadius   =  25.
  ZoneRadius  = 100.
  CountyList  = YES
  County      = 01017
  County      = 13013
  County      = 13015
!
! MICROENVIRONMENT PARAMETERS
  #Micros     = 12
!
! COMMUTING PARAMETERS
  Commuting   = YES
  KeepLeavers = YES
  LeaverMult  = 0.0
  LeaverAdd   = 0.0
!
! DIARY SELECTION PARAMETERS
  AgeMin      =  0
  AgeMax      = 99
  ChildMin    =  5
  ChildMax    = 18
  MissGender  =  0.0
  MissEmpl    =  0.0
  MissAge     =  0.0
  AgeCutPct   = 20.0
  Age2Probab  =  0.05
!
! DOSE PARAMETERS
  COHbFact    = 2.5
!
!LOCATION PARAMETERS
 CustomWork   =
 SampleOtherLocs = YES
 #OtherDistricts = 2
 HomeProbab   = 0

! ROLLBACK PARAMETERS
  Rollback    = NO
  RBtarget    =  5.0
  RBbackgnd   =  0.0
  RBmax       = 10.0
```

```
!
! DIAGNOSTICS PARAMETERS
  DebugLevel  = 0
!
! LOG FILE SWITCHES
  LogDistrict = NO
  LogPopulate = NO
  LogProfiles = NO
  LogSectors  = NO
  LogTables   = NO
  LogZones    = NO
  VAOutput    = NO
!
! OUTPUT FILE SWITCHES AND KEYWORDS
 EventsOut    = YES
 EventSample = 2
 CustomSample = 3092
 MResOut      = NO
 MSumOut      = NO
 HourlyOut    = NO
 DailyOut     = YES
 PSumList     = AVGEXP,MAXEXP,AVGEXP,MAXEXP
 HourlyList   = CONC1, AMB, EXP, EVR, VE, VA, EE, METS, EF
 DailyList    = MAX1DOSE  MAX8DOSE  MAX1FDOSE  AVGDOSE
 MResList     = VOL, AER, RR, PRX, PEN, CSUM, AMB
 MResHome     = YES
 MResMicros   = 1,2,8,12
!
! TABLES PARAMETERS
  HeavyEVR1    = 30
  HeavyEVR8    = 99
  ModEVR1      = 16
  ModEVR8      = 13
  ActivePAI    = 1.76
!
! LONGITUDINAL DIARY PARAMETERS
  LongitDiary  = YES
  DiaryAutoC   = 0.19
  DiaryD       = 0.22
```

Exhibit 4-4. Job Parameters Sections of the Simulation Control File

4.3 Population Sector Location File

The *Population Sector Location* file provides the latitude and longitude of a representative location such as the geographic center of all the sectors (e.g., census tracts) to be included in the population data files. Each line includes a ***Sector ID***, ***Latitude***, and ***Longitude***. The sector ID may be any string, numeric or character, and is stored as a character string (up to length 40). The string may contain any characters except ! or embedded spaces. The sector ID must match the sector IDs in the *Commuting Flow* file (if worker commuting is being modeled). The ID is case-sensitive, so the values in the two files must match exactly.

The population sector location file is used along with the user-specified ***CityRadius*** to automatically select population sectors within the study area (after also addressing an optional county test and ensuring suitable air district and meteorology zone data). APEX calculates the distance between the location of a sector and the center of the study area and then compares it with the ***CityRadius***. Sectors with a distance from the study area center greater than the city radius will not be included in the exposure assessment.

The tract-level population sector location file supplied with APEX contains the 11-digit ID and latitudes and longitudes of the year 2000 U.S. Census tracts. APEX expects that the left-most five characters of a sector ID will be the state and county FIPS code or the county-level code used in the ***County*** list (if the study area will be limited in that way).

The latitude and longitude should be in decimal degrees. At least three significant digits should be provided after the decimal point to prevent significant rounding error. Note that the longitude west of the prime meridian (e.g., United States locations) should be negative. Exhibit 4-5 provides an example of the first few records of this input file.

```
! Population census tract locations
! Tract ID          Latitude        Longitude
01001020100         32.470986      -86.487033
01001020200         32.466056      -86.472934
01001020300         32.474035      -86.457764
01001020400         32.466794      -86.445569
01001020500         32.454933      -86.425025
01001020600         32.439950      -86.478442
01001020700         32.438025      -86.443068
01001020800         32.502299      -86.495082
01001020900         32.644428      -86.501249
...
```

Exhibit 4-5. First Part of Population Sector Location File

4.4 Air District Location File

The *Air District Location* file provides the ***Site ID***, ***Latitude***, ***Longitude***, air data ***Start Date***, and air data ***End Date*** for all air quality (modeling or monitoring) sites included in the *Air Quality Data* file (Section 4.5). The site ID may be any string, numeric or character, and is stored as a character string (up to length 40), but must not contain an ! character or embedded spaces. Latitude and longitude are in decimal degrees. The start and end dates are in YYYYMMDD format (for example, 19951231 is December 31, 1995). The IDs and order of the listed sites must match those in the *Air Quality Data* file exactly (IDs are case-sensitive). It is good practice to insert a comment on the first line of the file to indicate the source or type of data used for air quality. See Exhibit 4-6 for an example of the first few records of an *Air District Location* file.

```
! Hourly ozone air quality districts for an example metropolitan area
! This file contains the locations of 105 air quality districts
! Created on November 4, 2005
0000100010 34.371470 -85.461103 20040301 20041031
0000100009 34.194947 -85.461103 20040301 20041031
0000100008 34.018423 -85.461103 20040301 20041031
0000100007 33.841899 -85.461103 20040301 20041031
0000100006 33.665375 -85.461103 20040301 20041031
0000100005 33.488851 -85.461103 20040301 20041031
0000100004 33.312327 -85.461103 20040301 20041031
0000100003 33.135804 -85.461103 20040301 20041031
0000200011 34.547994 -85.239577 20040301 20041031
```

Exhibit 4-6. First Part of Example Air District Location File

APEX uses the *Air District Location* file to determine the "air district" or geographical area represented by the ambient air quality data for a specified location. All pollutants use the same air districts and thus there is only one file of this type. APEX first compares the start and end dates for each air quality site with the start and end dates for the APEX exposure simulation. Only the sites with air quality data covering the entire simulation period are accepted. If a site is encountered with incomplete data, APEX prints a warning to the log file and stops execution. Air quality data in the file before or after the simulation period are simply ignored.

APEX then calculates the distance of an air district location from the study area center and compares it with the sum of ***CityRadius*** and ***AirRadius***. This allows air quality data to be used from a nearby (and the nearest) air district even if the air district's location is outside the study area. Only the sites with a distance less than this sum are retained for further calculations.

APEX then calculates the distances of a site from the locations of sectors (e.g., census tracts). Sectors with distances less than ***AirRadius*** will be mapped to an air site. Based on this mapping, APEX will use each set of air quality data in the *Air Quality* file only for the sectors within its AirRadius. APEX assigns the sector to the nearest air district. Each sector is assigned to only one air district. Sectors within the study area that lack a matching air district are not included in the simulation.

Not all air districts on the air quality input file need sectors assigned to them. Such air districts are simply not included in the modeling. This feature allows the user to prepare an input file in the simplest manner, perhaps containing more air districts than are necessary. For example, a single input file could be prepared for all air districts in a given state. This same input file could then be run on several study areas in the state without having to alter the air quality input file.

Internally, APEX refers to air quality districts by a sequential index (district #1, #2, etc.) that is assigned when the district-sector mapping is established. The *Log* file for the model run reports the names and locations for each air quality district number. Note that district #1 for a particular study area might not always mean the same location on the ground for all model runs. For example, if a series of runs for different years in Denver were performed, different monitors might be online during different years, in which case district #1 might change meaning from year to year. This can be avoided by preparing an *Air Quality Data* input file (see next Section) that has complete data for all air quality districts for all years being modeled, in which case the mappings should remain the same from year to year.

4.5 Air Quality Data File

This file provides air concentration data for air sites listed in the *Air District Location* file for a given pollutant; there is one file of this type for each pollutant in the simulation. Only keyword or numeric input lines are processed and other types of input lines are ignored in this file, with the exception of the first line which (even if it is a comment) is always echoed to the header in each output file. Therefore, the first line should contain information describing the simulation and pollutant.

There are two different types of AQ data files that may be used in APEX. The first type of file simple contains values of the air quality data for each air district for each timestep (for example, hour) in the simulation. The second type of AQ data file contains distributions that allow for person-to-person variability in the AQ data for each hour of the simulation. This type of file may only be used when the APEX timestep is 1 hour. APEX accepts raw AQ data (type 1) by default, if a type 2 file is to be used the user must set the *Control* file flag **ModelAQData** =YES.

The formats of two types of files are described in detail below.

4.5.1 Raw AQ Input Data

This type of AQ file is the APEX default, and will be adequate in most cases. Within this file the data for each site begins with a header section containing the site ID or ***Name*** (see Exhibit 4-7). Recall that these site IDs must match those in the *Air District Location* file exactly; the IDs are case sensitive and must not contain an ! or embedded spaces. The sites can be in any order in this file. APEX locates the air data set by matching a site name in the *Air district Location* file with the site name in this file. There can be no missing data within the simulation period.

Each of the subsequent numeric records includes a list of ***Timestep Average Air Concentrations*** followed by a ***Date***. The date should be in YYYYMMDD format (e.g., 20010507 is May 7, 2001). Air quality data should be in the units specified in the Control file for the pollutant. The data values can be either comma or space delimited. Note that the length of each data line in an air quality file should not exceed 5000 characters. Foe example, if the APEX timestep is one hour, each numeric record will list 24 hourly average concentration values, followed by a date. If the APEX timestep is 5 minutes, then each line have 288 5-minute averages followed by the date. An example of the beginning portion of this type of file is given in Exhibit 4-7.

```
! Ozone air quality data for an example metropolitan area
! For 105 air quality districts, for the period 03/01/04 to 10/31/04
! Created on November 4, 2005
Name = Site0000100003
0.01553 0.01825 0.02621 0.02989 0.02975 0.02650 0.02310 ... 0.03891 20040301
0.03822 0.03738 0.03749 0.03754 0.03687 0.03550 0.03240 ... 0.00948 20040302
0.00577 0.00570 0.00528 0.00477 0.00394 0.00453 0.00430 ... 0.01169 20040303
0.01456 0.01828 0.01916 0.01810 0.01547 0.00925 0.00591 ... 0.03326 20040304
0.03354 0.03244 0.02412 0.01705 0.01293 0.01076 0.01066 ... 0.02849 20040305
```

Exhibit 4-7. First Part of Example Air Quality Data File (Raw Data Type)

4.5.2 AQ Input Defined as Hourly Distributions

This type of AQ input data can be used to model person-to-person variability within an hour within an AQ district. This type of data can only be used if the APEX timestep is equal to 1 hour (**TimestepsPerDay**=24, the APEX default).

Within this file the data for each site begins with a header section containing the site ID or ***Name*** (see Exhibit 4-7). Recall that these site IDs must match those in the *Air District Location* file exactly; the IDs are case sensitive and must not contain an ! or embedded spaces. The sites can be in any order in this file. APEX locates the air data set by matching a site name in the *Air district Location* file with the site name in this file. There can be no missing data within the simulation period.

In this type of AQ file, each numerical record begins with a date and an hour number, followed by any APEX distribution definitions. See Table 3-1 and *Volume II* for a discussion of available probability distributions in APEX. If this type of input is to be used, the *Control* file flag **ModelAQVar** must be set to Y, otherwise an APEX error will result. An example of the first part of an AQ Data file (distribution type) is shown below in Exhibit 4-8. In this example, the AQ value for each hour is defined by a normal distribution. The ambient AQ value for the hour for will be sampled from this distribution for each person in the Air Quality district.

```
! Hourly ozone air quality distributions for an example metropolitan area
! This file contains data for 127 air quality districts, for the period 01/01/04 to 12/30/04
! Created on February 26, 2008 for testing new APEX code. KKI.
! Format is Date  Hour DistributionDef
! Where DistributionDef is any standard APEX distribution definition
Name =0000200006
! Date    Hr Distribution
 20040101  1 Normal  0.01066   .00005  .  .  0  0.10  Y
 20040101  2 Normal  0.01121   .00005  .  .  0  0.10  Y
 20040101  3 Normal  0.01184   .00005  .  .  0  0.10  Y
 20040101  4 Normal  0.01067   .00005  .  .  0  0.10  Y
 20040101  5 Normal  0.01231   .00005  .  .  0  0.10  Y
 20040101  6 Normal  0.01515   .00005  .  .  0  0.10  Y
 20040101  7 Normal  0.01537   .00005  .  .  0  0.10  Y
```

Exhibit 4-8. First Portion of an Air Quality Data file (Distribution Type).

4.6 Meteorology Zone Location File

The format and use of the *Meteorology Zone Location* file is analogous to the *Air District Location* file. Each record represents one site, and contains five values: ***Site ID***, ***Latitude***, ***Longitude***, ***Start Date***, and ***End Date***. Again, the Site ID may be any string up to 40 characters long; it cannot contain an ! or embedded spaces. The IDs must match those in the *Meteorology Data* file exactly; the IDs are case sensitive. The site selection process is also analogous to that described above for the *Air District Location* file. The file is used to map the set of meteorology data collected at a weather station to sectors within its zone radius for exposure calculations. An example file is provided in Exhibit 4-9. Similar to air districts, zones within the sum of ***CityRadius*** and ***ZoneRadius*** are used. Study area sectors for which no meteorology data are available are not included in the simulation.

APEX makes an internal list of meteorological zones that have sectors assigned to them and assigns them sequential numbers for convenience. This mapping is reported in the *Log* file, which is output from each model run.

```
! Example APEX4 Meteorological Station Locations (Zones) File
! Created 11/4/05
03812    35.4333   -82.5333  20040101 20041231
03813    32.7000   -83.6500  20040101 20041231
03816    37.0667   -88.7667  20040101 20041231
03820    33.3667   -81.9667  20040101 20041231
03856    34.6500   -86.7667  20040101 20041231
03870    34.9000   -82.2167  20040101 20041231
03937    30.1167   -93.2167  20040101 20041231
```

Exhibit 4-9. First Part of Example Meteorology Zone Location File

4.7 Meteorology Data File

This file provides hourly temperature and meteorological data for the sites listed in the *Meteorology Zone Location* file. Only numeric input lines or lines containing the keyword “name” followed by an equal sign are processed. All other types of input lines are ignored. The meteorology sites may be in any order in this file. The section of data for each site must begin with the “name” keyword input line. An example is shown in Exhibit 4-10. The site names (site IDs) must match those in the *Meteorology Zone Location* file exactly; the IDs are case sensitive and must not contain an ! or embedded spaces.

APEX matches a site name in the *Meteorology Zone Location* file with the data set site name to locate its data in this file. If desired, the user could add more comment lines in the header section of a data set.

Temperatures can be used to assign activity diaries to days (via the profile function DiaryPools, see Section 4.15), and any meteorological variable present in the file may be used as conditional variables for microenvironment parameters (see Section 4.15.2 and *Volume II*).

The “site name” input line is followed by the meteorological data. Each data line may contain the following data:

- Date (YYYYMMDD)
- Hour (1-24)
- Temperature (degrees Fahrenheit)
- Relative Humidity (percent)
- Precipitation (character code, see below)
- Wind speed (km per hour)
- Wind Direction (degrees from north)

The data do not have to be in fixed columns and may be separated by whitespace only.

The numerical data may be integer or real (decimal) – they are translated to integers when the file is read.

The precipitation code may be any character string, up to 12 characters in length (no spaces), although it is assumed that this code will be no more than 2 letters under normal circumstances. (The codes used for precipitation must match those used in the *Profile Functions* file, see Section 4.15).

Not all variables need to be defined in the file; only temperature is required. If a variable is to be included, though, all variables before it on the data line must be defined. For example, if the user wishes to include wind speed, then precipitation must exist in the file in order for it to be read correctly. Note that this does not imply that the user must use precipitation in the model run (for example, to set microparameter distributions, see Section 4.15). Therefore, a dummy code could be entered for precipitation in this case.

Each data set should cover the exposure simulation period. A data set can include more days than the exposure simulation period; APEX only uses the data within the simulation period. Thus, the user may prepare a file with a full year or many years of data for each site and then use the same meteorology file for a series of different simulation periods. There can be no missing data within the simulation period.

```
!Hourly Meteorological Data
!Date      Hr  Temp         Humidity    Prec  Windspeed   Direction
name=03812
20040101   1   64.0000000   30.0000019   RA   12.0000038   180.0000458
20040101   2   64.0509644   30.1274014   CL   12.2548046   182.5480499
20040101   3   64.7050323   31.7625809   RA   15.5251617   215.2516174
20040101   4   65.3338318   33.3345718   CL   18.6691437   246.6914520
20040101   5   65.9261093   34.8152771   CL   21.6305542   276.3055420
20040101   6   65.6765747   34.1914406   CL   20.3828812   263.8288269
...
name=03813
20040101   1   66.1480103   30.3700294   CL   12.7400570   187.4005737
20040101   2   67.6218567   34.0546417   CL   20.1092834   261.0928345
```

```
20040101   3   67.6839142   34.2097778   CL   20.4195595   264.1955872
20040101   4   66.9728241   32.4320602   CL   16.8641205   228.6412048
20040101   5   66.3958359   30.9895973   CL   13.9791956   199.7919617
20040101   6   66.9397125   32.3492851   CL   16.6985664   226.9856720
...
```

Exhibit 4-10. Example Portion of Meteorology Data File

4.8 Population Data Files

Each *Population Data* file contains sector-level data for a single gender/race combination. Ten gender/race specific population data files for all year 2000 Census tracts have been prepared and provided with the APEX release. However, user-defined population data files may be constructed, if the format given below is followed.

The population files contain the population counts for each sector contained in the *Sector Location* file. In general, each population file is for a single race/gender combination, although composite files containing more than one gender or race can be used. The population counts are given by age group. The age groups are designated in the first part of the file (the descriptor records).

Four descriptor records must appear in each population file. These records must appear immediately after any header comment records (which start with "!") and before the population data records (i.e., the actual population counts). The data on these four records are read starting to the right of the '=' sign, if present. Text descriptors to the left of the '=' signs are optional. The contents of these four records must be as follows:

Descriptor record 1: ***Gender, Race*** (5 characters), Number of population groups
Descriptor record 2: Race description (may contain blanks, up to 200 characters)
Desc*riptor record 3*: Minimum age for each group
Descriptor record 4: Maximum age for each group

The fields in descriptor records 1, 3 and 4 are space-delimited. Gender must be "Female" "Male" or "All". The 5-character label for race also appears as a column header on the *Profile Summary* output file. If the population files provided with APEX are to be used, the ***Race*** must be White, Black, Asian, NatAm, or Other, which may be shortened to W, B, A, N, or O. If the user provides the population files, ***Race*** could be different. For example, if one file each is given for all males and all females, ***Race*** could be specified as *All*. However, it is necessary for ***Race*** to match the designation in the *Control* file, or a Fatal error will result.

The race description is not used, but is echoed in the log file for the benefit of the user. Only the shorter 5-character race label that is given on the first line is written to the other output files, to save space.

The next two records specify the minimum and maximum ages for the age groups. The ages must be delimited by a single space. Note that all the population data files must contain the same number of population groups, and furthermore, all the group age limits (minima and maxima) must match as well, or APEX will exit with a Fatal error. The population files provided with APEX contain single-year age groups.

The actual population data follows the descriptors records. Each population record has the ***Sector ID*, (**which must match the IDs in the *Sector Locations* file exactly, and thus can be any alphanumeric string of 40 or fewer characters without embedded spaces or an !) followed by a ***Count*** for each population age group (youngest first). The counts are the number of people in a given age group living in the sector; they must be delimited by a single space. Each *Population Data* file used in a model run must have a record for each sector listed in the population Sector Location file or a Fatal error will result. The sectors do not necessarily have to be in the same order in every population file in order for APEX to run, however, a warning message will result if APEX finds that the order of the sectors in any population file differs from the order of the sector list. A single error message will be written for each population file having out-of-order sectors, no matter how many differences are found. APEX will exit with a Fatal error message if a sector in the final list of study area sectors cannot be found in a population file.

Exhibit 4-11 provides an example of a portion of a *Population Data* file.

```
! Population file by census tract, extracted from 2000 census
! File prepared by ManTech Environmental Technology, Inc., Apr 2003
Gender,Race,#Ages = Female, Asian, 100
Race description  = Asian or Pacific Islander
Age group minimum = 0 1 2 3 4 5 6 7 8 9 10 11 12 ... 98 99
Age group maximum = 0 1 2 3 4 5 6 7 8 9 10 11 12 ... 98 99
!
01001020100 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 ... 0 0
01001020200 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 ... 0 0
01001020300 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 ... 0 0
01001020400 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 ... 0 0
01001020500 0 2 0 1 1 0 1 2 1 0 1 0 0 0 0 0 0 ... 0 0
01001020600 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 ... 0 0
```

Exhibit 4-11. First Part of a Population Data File

4.9 Commuting Flow File

This file provides cumulative fractions of the population in a home sector that commute to different work sectors. An example portion of this file is provided in Exhibit 4-12. Each section of commuting data in the file contains a Home Sector and each of the corresponding Work Sectors for the home sector. All sector IDs in this file must be exactly identical to those contained in the *Sector Location* file (i.e., they are case sensitive and must not contain an ! or embedded spaces). The first record of each section lists the ***Home Sector ID*** followed by a -1. This -1 has no meaning; it is simply used by APEX to recognize the beginning of a new data section (i.e., a new home sector). After the home sector record, each of the work sectors for that home sector is listed. Each work sector record contains the ***Work Sector ID***, a ***Cumulative Fraction*** of the home sector population commuting to this work sector, and the Distance (km) between the home sector and the work sector. (The distance is not used by the current release of

APEX and thus may be omitted if desired.) The cumulative fraction for the last work sector in each group should always be equal to 1. APEX uses this file to determine which work sector a simulated individual may commute to by using the cumulative fractions as commuting probabilities.

The user can create their own commuting databases using the format given above, recalling that the sectors in the commuting file must correspond to those in the *Sector Location* file. For example, if a user creates a *Sector Location* file that contains sectors corresponding to spatial units smaller than census tracts, a corresponding *Commuting Data* file would have to be constructed as well in order to model commuting.

If the sectors used in the simulation are year 2000 Census tracts, the commuting flow file provided with APEX can be used. This database contains all the year 2000 Census tracts and their associated work tracts. The mean number of associated work tracts per home tract is 79, with a minimum of 1 and a maximum of 413.

```
! APEX U.S. Tract-Level Commuting File from 2000 Census
! Prepared by Alion Science and Technology, January 2005
! ID cumFrac km
01001020100 -1.00000 -1.0
01001020700 0.10412 5.5
01101000100 0.20097 19.6
01001020600 0.28814 3.5
01001020500 0.36804 6.1
01001020200 0.44068 1.4
01001020300 0.49153 2.8
01001020400 0.53632 3.9
```

Exhibit 4-12. First Part of the Commuting Flow File

4.10 Employment Probability File

A nationwide employment probability file has been prepared for ages 16 and above, covering all the tracts from the 2000 census. Each record (tract) contains 26 probabilities (13 age groups each for males and females). The age groups in the provided file are for ages 16-19, 20-21, 22-24, 25-29, 30-34, 35-44, 45-54, 55-59, 60-61, 62-64, 65-69, 70-74, and 75 and older.

The employment probability age groups do not have to match the population file age groups, providing increased flexibility in the demographic inputs to APEX. Users may create their own employment files, as long as the file format is followed. The ages in the employment file may extend beyond those in the population files, but be aware that APEX will never generate a profile outside of the ages in the *Population Data* files.

An example portion of the Employment Probability file is given in Exhibit 4-13. The file contains optional header lines, followed by three required lines. The first required line reports the gender for each column of data, the second line reports the age group minimum, and the third line reports the age group maximum. Below that, each line starts with the sector ID, followed by a vector of decimal probabilities (one per column). The first item on each line below the header lines is the sector ID, followed by the eight employment probabilities for that sector. Each probability in the national file is calculated by dividing the number of employed persons by the total sector population for the specified age range and gender. Whenever the total sector population for a particular age range and gender is zero, then obviously the employed persons must also be zero. These data are reported as zero probabilities in the file. It should not matter what values are assigned, since no simulated persons of that type should ever be generated by the model. Note that a custom employment probability file must be created if custom *Population Data* files are used. That is, the sectors in the employment probability file must match those in the population files.

Note that any ages not covered by one of the employment age groups will automatically have an employment probability of zero. In the example below this would apply to persons younger than age 16.

```
! Employment probability fractions by gender and age group from 2000 census
! Prepared by ManTech Environmental Technology, Inc. for EPA in April 2003
Gender=     M        M        M        M        ...  F        F
MinAge=     16       20       22       25       ...  70       75
MaxAge=     19       21       24       29       ...  74       200
01001020100 0.39744  1.00000  0.32258  0.83636  ...  0.00000  0.00000
01001020200 0.45283  0.26415  0.70588  0.79167  ...  0.00000  0.12500
01001020300 0.55056  0.82857  1.00000  0.95200  ...  0.08475  0.00000
01001020400 0.34921  0.79310  1.00000  0.91818  ...  0.19192  0.00000
01001020500 0.57143  0.88889  1.00000  0.96503  ...  0.00000  0.00000
01001020600 0.64583  1.00000  1.00000  0.87500  ...  0.08621  0.00000
01001020700 0.38554  0.48571  0.91304  0.90698  ...  0.37500  0.07692
01001020800 0.29712  0.56757  1.00000  0.79693  ...  0.00000  0.03191
```

Exhibit 4-13. Excerpt from the Employment Probability File

4.11 MET Mapping File

This file maps each CHAD (or other database) activity code to an internal APEX distribution number, for calculating the energy expended by a simulated person for each diary event. Energy expenditures are used for estimating activity level and ventilation for each simulated person. These quantities are used for used in creating tables of exposures at different exertion levels and for estimating pollutant dose. A MET value is a dimensionless ratio of the activity-dependent energy expenditure rate to the basal or resting energy expenditure (metabolic) rate, and the CHAD activity code is an identifier associated with each diary event that indicates the type of activity being performed. The current CHAD activity codes are given in Table 4-5.

Table 4-5. CHAD Activity Codes

Activity Code	*Description*	*Activity Code*	*Description*
10000	Work and other income producing activities, general	13600	Obtain car services
		13700	Other repairs
10100	Work, General	13800	Other services
10110	Work, general, for organizational	14000	Personal needs and care, general

Activity Code	Description	Activity Code	Description
	activities		
10111	Work for professional/union organizations	14100	Shower, bathe, personal hygiene
10112	Work for special interest identity organizations	14110	Shower, bathe
		14120	Personal hygiene
10113	Work for political party and civic participation	14200	Medical care
		14300	Help and care
10114	Work for volunteer/ helping organizations	14400	Eat
10115	Work of/for religious groups	14500	Sleep or nap
10116	Work for fraternal organizations	14600	dress, groom
10117	Work for child / youth / family organizations	14700	Other personal needs
10118	Work for other organizations	15000	General education and professional training
10120	Work, income-related only	15100	Attend full-time school
10130	Work, secondary (income-related)	15110	Attend day-care
10200	Unemployment	15120	Attend K-12
10300	Breaks	15130	Attend college or trade school
11000	General household activities	15140	Attend adult education and special training
11100	Prepare food	15200	Attend other classes
11110	Prepare and clean-up food	15300	Do homework
11200	Indoor chores	15400	Use library
11210	Clean-up food	15500	Other education
11220	Clean house	16000	General entertainment / social activities
11300	Outdoor chores	16100	Attend sports events
11310	Clean outdoors	16200	Participate in social, political, or religious activities
11400	Care of clothes		
11410	Wash clothes	16210	Practice religion
11500	Build a fire	16300	Watch movie
11600	Repair, general	16400	Attend theater
11610	Repair of boat	16500	Visit museums
11620	Paint home / room	16600	Visit
11630	Repair / maintain car	16700	Attend a party
11640	Home repairs	16800	Go to bar / lounge
11650	Other repairs	16900	Other entertainment / social events
11700	Care of plants	17000	Leisure, general
11800	Care for pets/animals	17100	Participate in sports and active leisure
11900	Other household	17110	Participate in sports
12000	Child care, general	17111	Hunting, fishing, hiking
12100	Care of baby	17112	Golf
12200	Care of child	17113	Bowling / pool / ping pong / pinball
12300	Help / teach	17114	Yoga
12400	Talk /read	17120	Participate in outdoor leisure
12500	Play indoors	17121	Play, unspecified
12600	Play outdoors	17122	Passive, sitting
12700	Medical care-child	17130	Exercise
12800	Other child care	17131	Walk, bike, or jog (not in transit)
13000	Obtain goods and services, general	17140	Create art, music, participate in hobbies
13100	Dry clean	17141	Participate in hobbies

Activity Code	Description	Activity Code	Description
13200	Shop / run errands	17142	Create domestic crafts
13210	Shop for food	17143	Create art
13220	Shop for clothes or household goods	17144	Perform music / drama / dance
13230	Run errands	17150	Play games
13300	Obtain personal care service	17160	Use of computers
13400	Obtain medical service	17170	Participate in recess and physical education
13500	Obtain government / financial services	17180	Other sports and active leisure

Each of the CHAD codes is mapped to an internal APEX distribution number; activities that have identical energy expenditure associated with them map to the same distribution. The distributions themselves are defined by number in the *MET Distribution* File (section 4.12). Each line of the *MET Mapping* file contains a

- ***Activity Code.*** This activity code maps the CHAD activity to the internal APEX distribution number.
- ***Age Category.*** Some MET distributions are differ for persons of different ages. This variable maps the age groups to the correct distribution number. The age category given in this file is a label representing the age group. APEX will assign distributions as follows:
  - -Age is "0": APEX will use for persons of all ages
  - -Age is "20": APEX will use for persons age 0 to 25
  - -Age is "30": APEX will use for persons age 26 to 39
  - -Age is "40": APEX will use for persons age 40 and older
- ***Occupation.*** The MET distributions for the "Work" CHAD activity differ based on the occupation of the profile. This variable maps the different occupations to the correct distribution number.
- ***MET Distribution Number.*** This is an internal index used by APEX to access the distribution. These values range from 1 to 166. They may be expanded to distribution number 256 if necessary.
- ***Notes.*** Description of the activity being modeled by the MET distribution. This is for the convenience of the user and is not used internally by APEX.

An example portion of the MET Mapping File is given in Exhibit 4-14.

```
! METS Distribution Mapping file
! Created 12-12-2006
Activity Age  Occ.   APEX Dist# Notes
10000    0    ADMIN      1      Work, general
10000    0    ADMSUP     1      Work, general
10000    0    FARM       2      Work, general
10000    0    HSHLD      3      Work, general
10000    0    LABOR      4      Work, general
10000    0    MACH       5      Work, general
10000    0    PREC       6      Work, general
10000    0    PROF       7      Work, general
10000    0    PROTECT    7      Work, general
10000    0    SALE       7      Work, general
10000    0    SERV       8      Work, general
10000    0    TECH       9      Work, general
10000    0    TRANS      10     Work, general
10000    0    X          11     Work, general
10300    0    Any        12     Breaks
11000    0    Any        13     General household activities
11100    0    Any        14     Prepare food
11110    0    Any        15     Prepare and clean-up food
11200    0    Any        16     Indoor chores
11210    0    Any        17     Clean-up food
```

Exhibit 4-14. Example Portion of the MET Mapping File.

The user should not change this file unless the user has developed her own activity codes.

4.12 MET Distribution File

This file provides the actual distributions for calculating the MET value for each diary event (activity). The distributions are defined by APEX distribution number as given in the *MET Mapping* file. A MET value is a dimensionless ratio of the activity-dependent energy expenditure rate to the basal or resting energy expenditure (metabolic) rate, and the CHAD activity code is an identifier associated with each diary event that indicates the type of activity being performed. In general, the user should not change the distributions in this file, as these data were developed from extensive experimental data on human energy expenditures.

The distribution definitions make use of the standard APEX distribution format (a distribution shape, followed by 4 distribution parameters, upper and lower truncation bounds, and a resampling flag). The 4 parameters used are dependent on the shape of the distribution. Each data line in this file provides the following information in list format:

- ***APEX Distribution Number.*** This is an internal index used by APEX to access the distribution. These values range from 1 to 166. They may be expanded to distribution number 256 if necessary. This matches the distribution numbers used in the *MET Mapping* file.
- ***Distribution Shape.*** This variable gives the type of the MET distribution.
- ***Par1***. Parameter 1 of the MET distribution.

- ***Par2***. Parameter 2 of the MET distribution.
- ***Par3***. Parameter 3 of the MET distribution.
- ***Par4***. Parameter 4 of the MET distribution.
- ***LTrunc***. Lower truncation point of the MET distribution.
- ***UTrunc***. Upper truncation point of the MET distribution.
- ***ResampOut***: Distribution resampling flag.
- ***General Use.*** Text description of the general use of the particular distribution in APEX. Optional – not used by the model code.

Volume II provides complete details for defining probability distributions in APEX; a summary of the available distributions is given in Table 4-6.

Table 4-6. Available Probability Distributions in APEX.

Distribution	APEX KEYWORD	Par1	Par2	Par3	Par4	LTrunc (Optional)	UTrunc (Optional)	ResampOut (Optional)
Beta	BETA	Minimum	Maximum	Shape1 (s1) > 0	Shape2 (s2) > 0	Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Cauchy	CAUCHY	Median	Scale (b) > 0			Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Discrete	DISCRETE	This type of distribution has no parameters, rather the keyword is simply followed by a list of up to 100 discrete values. The distribution returns each of these values with equal probability.						
Exponential	EXPONENTIAL	Decay constant, k > 0	Shift (a)			Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Extreme Value	EVALUE	Scale (b) > 0	Shift (a)			Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Gamma	GAMMA	Shape (s) > 0	Scale (b) > 0	Shift (a)		Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Logistic	LGT	Mean	Scale (b) > 0			Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Lognormal	LOGNORMAL	Geometric mean (gm) of unshifted dist	Geometric standard deviation (gsd) > 1	Shift (a)		Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Loguniform	LUNIFORM	Minimum > 0	Maximum > 0			Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Normal	NORMAL	Mean	Standard deviation			Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
OffOn	OFFON	Probability of being 0 (0-1)						

Distribution	APEX KEYWORD	Par1	Par2	Par3	Par4	LTrunc (Optional)	UTrunc (Optional)	ResampOut (Optional)
Pareto	PARETO	Shape (s) > 0	Scale (b) > 0	Shift (a)		Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Point	POINT	Point Value						
Triangle	TRIANGLE	Minimum	Maximum	Peak		Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Uniform	UNIFORM	Minimum	Maximum			Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)
Weibull	WEIBULL	Shape (s) > 0	Scale (b) > 0	Shift		Lower truncation limit	Upper truncation limit	Resample outside truncation? (Y/N)

Periods (".") must be used as placeholders in the file if a parameter is not needed for a particular distribution.

See *Volume II: Technical Support Document* for further information about the use of MET probability distributions in APEX. A portion of this file is shown in Exhibit 4-15.

```
! APEX METS Distribution File
!Dist Shape      Par1  Par2    Par3  Par4   LTrunc   UTrunc    ResampOut General Use
1    Lognormal   1.7   1.2     0     .      1.4      2.7       Y         Work, admin
2    Lognormal   7     1.5     0     .      3.6      17        Y         Work, farm
3    Lognormal   3.5   1.2     0     .      2.5      6         Y         Work, household
4    Triangle    3.6   13.8    8.1   .      .        .         Y         Work, labor
5    Uniform     4     6.5     .     .      .        .         Y         Work, mech
6    Triangle    2.5   4.5     3.3   .      .        .         Y         Work, prec
7    Triangle    1.2   5.6     2.9   .      .        .         Y         Work,profess/protect/sales
8    Triangle    1.6   8.4     5.6   .      .        .         Y         Work, service
9    Triangle    2.5   4.5     2.9   .      .        .         Y         Work, tech
10   Lognormal   3     1.5     0     .      1.3      8.4       Y         Work, trans
11   Triangle    1.2   5.6     1.9   .      .        .         Y         Work, missing occup
12   Uniform     1     2.5     .     .      .        .         Y         Breaks
13   Triangle    1.5   8       4.6   .      .        .         Y         General household actv
14   Lognormal   2.5   1.2     0     .      2        4         Y         Prepare food
15   Exponential 1.11  1.9     .     .      .        4         Y         Prepare and clean-up food
16   Exponential 0.71  2       .     .      .        5         Y         Indoor chores
17   Uniform     2.3   2.7     .     .      .        .         Y         Clean-up food
18   Exponential 0.53  2.2     .     .      .        5         Y         Clean house
19   Normal      5     1       .     .      2        7         Y         Outdoor chores
20   Exponential 0.37  2.6     .     .      .        6         Y         Clean outdoors
21   Exponential 1.43  1.5     .     .      .        4         Y         Care of clothes
22   Point       2     .       .     .      .        .         Y         Wash clothes /build fire
23   Normal      4.5   1.5     .     .      2        8         Y         Repair, general
24   Point       4.5   .       .     .      .        .         Y         Repair of boat
25   Exponential 0.71  3.5     .     .      .        6         Y         Paint home / room
26   Triangle    3     4.5     3.01  .      .        .         Y         Repair / maintain car
```

Exhibit 4-15. Selected Parts of Activity-Specific MET File

4.13 Physiological Parameters File

This file provides age and gender specific distributions for a number of physiological parameters (see Exhibit 4-16). The parameters are listed in Table 4-7. See *Volume II: Technical Support Document* for details of these parameters and the equations in which they are used in APEX.

Table 4-7. Parameters in the Physiological Input File

Keyword	**Variable**	**Units**
NVO2MAX	Normalized maximum oxygen uptake	ml-O_2/(min-kg) (**Note**: while the APEX inputs for NVO2MAX are in ml-O_2/(min-kg), APEX outputs VO_2Max in the *Profile Summary* file in L-O_2/min)
BM	Body mass	kg
RMRINT	Intercept of resting metabolic rate regression	MJ/day (**Note**: while the APEX inputs for RMR are in MJ/day, APEX outputs RMR in the *Profile Summary* file in kcal/min).
RMRSLP	Slope of resting metabolic rate regression	MJ/(day-kg)
RMRERR	Standard deviation for resting metabolic rate regression	MJ/day
HMG	Blood hemoglobin density	g/dl
BSAEXP1	Exponent 1 for calculating body surface area	-
BSAEXP2	Exponent 2 for calculating body surface area	-
MAXOXD	Maximum oxygen deficit	ml/kg
BLDFAC1	Blood volume factor 1	ml/lb
BLDFAC2	Blood volume factor 2	ml/inches^3
HEIGHTINT	Intercept of height regression	inches
HEIGHTSLP	Slope of height regression	**children under 18:** inches/(year of age) **adults:** inches/ln(lbs body weight)
HEIGHTERR	Standard deviation of height regression	inches
ECF	Energy conversion factor	L-O_2/kcal
RECTIME	Time required to recover maximum oxygen deficit	hours
ENDGN1	Endogenous CO production rate 1	ml/min
ENDGN2	Endogenous CO production rate 2 (used for women in 2nd half of menstrual cycle)	ml/min

Distributions for the above parameters are assigned to persons of every age and gender combination in the *Physiology* file. The distributions are defined in the APEX distribution format (a distribution shape, followed by 4 distribution parameters, upper and lower truncation bounds, and a resampling flag - see *Volume II*). Thus, each data line contains the following information:

- ***Parameter*** keyword.
- ***Minimum age*** for the current parameter distribution definition.
- ***Maximum age*** for the current parameter distribution definition.
- ***Gender*** for the current parameter distribution.
- ***Distribution Shape***. This variable gives the type of the distribution.
- ***Par1.*** Parameter 1 of the distribution. Depends on shape.
- ***Par2***. Parameter 2 of the distribution. Depends on shape.
- ***Par3.*** Parameter 3 of the distribution. Depends on shape.
- ***Par4.*** Parameter 4 of the distribution. Depends on shape.
- ***LTrunc***. Lower truncation point of the distribution.
- ***UTrunc***. Upper truncation point of the distribution.
- ***ResampOut***: Distribution resampling flag.

Thus, each line of the physiology file can define the distribution for a range of ages, but only a single gender. The physiological parameters must be defined for both genders for all ages 0-100 years, with the exception of ENGN2, which need only be defined for females. An APEX fatal error will result if not all data are provided. In general, the distributions in this file should not be changed from their default values, as they were derived from available physiological data.

See Table 4-6 for the available distribution shapes and required parameters. Periods (".") must be used as placeholders if a parameter is not needed for a particular distribution.

```
! APEX Physiology Data, revised May 4, 2006
!Variable  AgeMin AgeMax    Gen       Shape     Par1    Par2     Par3  Par4  LTrunc   UTrunc ResampOut
!NVO2Max
NVO2MAX      0       0        M       Normal     48.3     1.7      .     .       44.3    52.2     N
NVO2MAX      1       1        M       Normal     48.6     2.0      .     .       43.8    53.3     N
NVO2MAX      2       2        M       Normal     48.9     2.4      .     .       43.4    54.4     N
NVO2MAX      3       3        M       Normal     49.2     2.7      .     .       43.0    55.4     N
NVO2MAX      4       4        M       Normal     49.5     3.0      .     .       42.5    56.5     N
NVO2MAX      5       5        M       Normal     49.8     3.3      .     .       42.1    57.6     N
NVO2MAX      6       6        M       Normal     50.1     3.7      .     .       41.6    58.6     N
NVO2MAX      7       7        M       Normal     50.4     4.0      .     .       41.2    59.7     N
NVO2MAX      8       8        M       Normal     50.8     4.3      .     .       40.8    60.8     N
NVO2MAX      9       9        M       Normal     51.1     4.6      .     .       40.3    61.8     N
.
.
.
! Body Mass
BM           0       0        M       Lognormal 7.8      1.301   0     .       3.6     11.8     N
BM           1       1        M       Lognormal 11.4     1.143   0     .       8.2     16.1     N
BM           2       2        M       Lognormal 13.9     1.146   0     .       9.8     20.9     N
BM           3       3        M       Lognormal 16.0     1.154   0     .       11.7    23.7     N
BM           4       4        M       Lognormal 18.5     1.165   0     .       11.1    28.1     N
BM           5       5        M       Lognormal 21.6     1.234   0     .       13.7    42.4     N
BM           6       6        M       Lognormal 23.1     1.213   0     .       16.1    41.1     N
BM           7       7        M       Lognormal 27.1     1.216   0     .       19.3    46.8     N
BM           8       8        M       Lognormal 31.7     1.302   0     .       19.1    66.2     N
BM           9       9        M       Lognormal 34.7     1.265   0     .       24.0    69.9     N
BM           10      10       M       Lognormal 38.3     1.280   0     .       24.3    72.9     N
BM           11      11       M       Lognormal 44.1     1.308   0     .       26.2    83.8     N
BM           12      12       M       Lognormal 48.0     1.315   0     .       27.7    94.8     N
.
.
.
! Intercept for RMR regression
RMRINT       0       2        M       Point      -0.127  .       .     .       .       .        .
RMRINT       3       9        M       Point      2.110   .       .     .       .       .        .
RMRINT       10      17       M       Point      2.754   .       .     .       .       .        .
RMRINT       18      29       M       Point      2.896   .       .     .       .       .        .
RMRINT       30      70       M       Point      3.653   .       .     .       .       .        .
RMRINT       71      100      M       Point      2.459   .       .     .       .       .        .
RMRINT       0       2        F       Point      -0.130  .       .     .       .       .        .
```

Exhibit 4-16. An Example Portion of the Physiological Parameters File

4.14 Ventilation File

This file contains a set of regression parameters used by APEX to estimate ventilation from the event MET. This is a small file of five lines, containing the parameters for each of five age groups (Exhibit 4-17). This file should not be edited except by advanced users who understand the APEX ventilation algorithm.

For more information on the ventilation algorithm and the derivation of the values in this file, see *Volume II*: *Technical Support Document* and Graham and McCurdy (2005).

```
! APEX4 Ventilation Data File
! MinAge MaxAge   b0     seb0    b1     seb1     b2      seb2    b3     seb3    eb     ew     R2
   0     19    4.4329  0.0579  1.0864  0.0097  -0.2829  0.0124   0.0513  0.0045  0.0955  0.1117  0.925
  20     33    3.5718  0.0792  1.1702  0.0067   0.1138  0.0243   0.045   0.0031  0.1217  0.1296  0.8927
  34     60    3.1876  0.1271  1.1224  0.012    0.1762  0.0335   0.0415  0.0095  0.126   0.1152  0.8922
  61    100    2.4487  0.3646  1.0437  0.0195   0.2681  0.0834  -0.0298  0.01    0.1064  0.0676  0.8932
```

Exhibit 4-17. The APEX Ventilation Input File

4.15 Profile Functions (Distributions) File

The *Profile Functions* input file defines functions for variables associated with each simulated profile. There are two types of functions that can be defined. They are:

- ***Functions for built-in APEX variables.*** These are variables that are predefined in APEX, and whose values under different circumstances can be customized by the functions defined in this file. Most of these variables are also "conditional variables" because microenvironmental parameters can depend on their values.

- ***Functions for creating user-defined APEX conditional variables***. These are generic variables that the user may define and then use in calculating microenvironmental parameters. These names of these variables have no set intrinsic meaning in APEX; they can be used to represent whatever the user wishes. Up to eight of these variables may be defined in APEX.

- ***Functions for creating user-defined APEX conditional variables that vary by region.*** These are generic variables that the user can define and then use for calculating microenvironmental parameters. These variables can vary by region (either county or sector) and thus may be evaluated differently for individuals who reside in these different regions. Up to five of these functions may be defined.

The relationships among the different functions that can be defined in the *Profile Functions* file and the microenvironmental descriptions are shown in Figure 4-1. The built-in and user-defined functions are used to define a set of conditional variables V_C, which are functions of input APEX variables (V_I). These conditional variables are used in determining microenvironmental parameters. Microenvironment parameters are quantities that appear in the equations for the microenvironmental concentrations. The relationship between the conditional variables and the microenvironment parameters are described in the *Microenvironmental Descriptions* file (see Section 4.19).

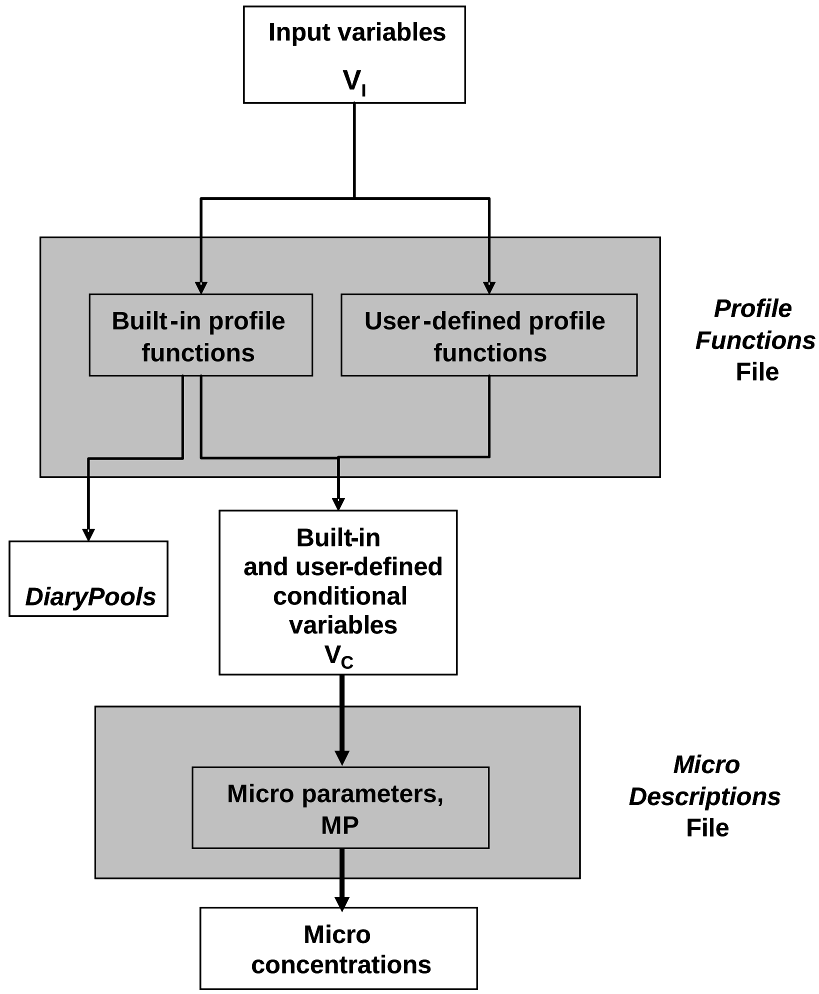

Figure 4-1. Relationship between Profile Functions and Microenvironmental Descriptions Files

4.15.1 Defining a Profile Function

The general procedure for defining a profile function is as follows:

1. A function definition begins with its name on the first input line.

2. The user may add as many comment lines as necessary to describe the profile function or units of the involved parameters.

3. If the function is of type regional (RegionalConditional1-5), then a statement is required to define how the regions are defined, either by county or sector, and how many different regions are being modeled.

4. The number of subsequent input lines varies with the number of input variables required to define the function. At least one (and usually two) input lines are needed for each input variable of the function. In addition, at least two lines are also needed for the function result. For each input variable (table dimension), the first line starts with the keyword ***INPUT***, followed by the indexing number of the variable in the function, the ***Type of Input Variable***, and the ***Number of Values*** **(Nvals)** allowed for the input variable. At the end of this input line, the user may add comments in double quotes to explain input variables. The lines directly following define the input variable data – specifically, they define how the input variable is grouped into integer categories for indexing the table of results. The ***Type of Input Variable*** must be one of the following:

- **probability**,
- **realrange**,
- **intrange**,
- **intvalue**,
- **intindex**, or
- **conditional**

Probability means fixed probabilities for each outcome (result). The input variable data for **probability** is a list of the Nvals fixed probabilities. The sum of the probabilities must equal 1. **Realrange** means a set of discrete categories, each consisting of a range of real numbers. In this case, the categories are defined by Nvals-1 cut points. (If the input variable falls on a cut point, it falls into the higher bin.) **Intrange** is similar, except each category consists of a range of integers. **Intvalue** means that each possible value that the input variable may take on is listed on the data line. **Intindex** means that the input variable is integer and is to be used to index the table of results directly (*e.g.*, a value of 3 means use the third cell a table dimension). Thus, this type of input variable does not require a second line. **Conditional** refers to conditional probabilities that depend on the values of other input variables. A **conditional** input variable comes last in a function specification. A table of probabilities follows. The number of entries in the probability table must be equal to the product of the number of category combinations for the other inputs and the number of possible function results.

See the examples in the sections that follow for illustration of the appropriate use of these input variable types.

5. After all the input variables are specified, the next line must contain the keyword ***RESULT***, followed by a type (integer, **real**, or **histogram**) and the number of possible results (Nresults).

6. The table results are then listed in order in subsequent lines. If the result type is designated as integer, the results must be a list of integers of length Nresults. If the type is **real**, then the list of results must contain Nresults real numbers. If the result type is **histogram**, the results are a series of Nresults+1 cut points that define Nresults bins.

7. The profile function ends with a new line that has a # sign.

The types of profile functions are discussed in detail below, with examples. Note that when preparing or editing a profile functions file, be careful not to use Tab to separate the items on a line. APEX explicitly searches for blanks (spaces) as delimiters, and does not recognize Tabs as such.

4.15.2 Functions for Built-in, User-defined, and Regional APEX Variables

The built-in APEX variables for which functions can be assigned are given in Table 4-8. All of these variables are conditional variables which can be used to define microenvironment parameters, with the exception of the variable DiaryPools. (Note that a few other APEX variables, such as gender, can be used as conditional variables, see Section 4.19.2). DiaryPools is the only function that APEX requires be defined, as it is used in the selection of appropriate CHAD diaries for different days in the simulation. The input variables required for each of these functions are hard coded; the required inputs for each variable are listed in the table. Also note that some conditional variables defined in this file must be used to define other conditional variables.

Three user-defined conditional variables are listed in the table as well. These functions take a single input variable, which must be defined by fixed probabilities for each of the function results (categories).

Each of the functions in the table returns an integer category for each combination of input parameters. For the conditional variables, these category numbers can be used in defining the microenvironment parameters in the Microenvironment Description File (see Section 4.19.2).

Three examples are shown in Exhibit 4-18. The first is the definition for a function for **AvgTempCat**. It returns an integer category number for the average temperature, which will be used in the definition of one or more microenvironment parameters. Recall that the input parameters for this function are fixed, and that the text in quotes is not used by APEX. The first and only input variable defines the integer ranges (via **intrange**) for the three categories of average temperature. In this case, the ranges are < 50 degrees, 50-77 degrees, and ≥ 78 degrees. The function essentially reads the daily average temperature and determines which category it falls in. The resulting categories are 1, 2 and 3. If the average temperature were 69 degrees, then the **AvgTempCat** function would return "2".

The second example is a definition for **WindowRes**. The first input variable is **AC_Home**, and the categories for it are defined by its two possible integer values (via **intvalue**), as 1 or 2. The second input variable is the maximum daily temperature; the categories for it are defined via **intrange** in a manner similar to that demonstrated in the first example. The third input variable, the average daily temperature, is also defined as **intrange**, but in this case there is only 1 category, which all temperatures fall into. (This is the correct way to ignore the influence of a required input variable). In this case, no cut points are required to be listed. The fourth and final input variable is the **conditional** probability for the two function results categories, 1 and 2. The probabilities for the results must be defined at all combinations of the categories for the first three input variables. The table of conditional probabilities loops first over the possible results, and then over the input variables, in order. So the first row of the table can be interpreted as containing the probabilities for **WindowRes**=1 and **WindowRes**=2 for **AC_Home**=1,

MaxTemp<56, and any **AvgTemp** value. The last line are the probabilities for **WindowRes**=1 and **WindowRes**=2 for **AC_Home**=2, **MaxTemp**>78, and any **AvgTemp** value. As expected, the probabilities for the two results sum to 1 for each combination of input variable categories.

Table 4-8. Variables That Can Be Defined in the Profile Functions File

Conditional Variable	Purpose	Input Variables	Number of Categories	Function Reevaluated
TempCat	Binning hourly temperatures into categories	INPUT1: Temperature on hour of simulation	any number	hourly
HumidCat	Binning hourly humidities into categories	INPUT1: Humidity on hour of simulation	any number	hourly
WindCat	Binning hourly wind speeds into categories	INPUT1: Wind speed on hour of simulation	any number	hourly
DirCat	Binning hourly wind directions into categories	INPUT1: Wind direction on hour of simulation	any number	hourly
PrecipCat	Assigning precipitation codes to categories	INPUT1: Precipitation code on hour of simulation	any number (equal to or less than the number of precipitation codes in the *Meteorology Data* file)	hourly
MaxTempCat	Binning daily maximum temperatures into categories	INPUT1: Temperature on hour of simulation	any number	daily
AvgTempCat	Binning daily average temperatures into categories	INPUT1: 24-hour average temperature on day of simulation (AvgTemp)	any number	daily
Diary Pools (Required)	Assigning diary pools	INPUT1: Maximum temperature on simulated day (MaxTemp) INPUT2: Average temperature on simulated day (AvgTemp) INPUT3: Day of the week	any number	daily
HasGasStove	Probability of having a gas stove	INPUT1: Probabilities for the 2 results	2 (Y/N)	once per profile
HasGasPilot	Probability of having a pilot light, conditional on HasGasStove	INPUT1: Has Gas Stove (Y/N)? (HasGasStove) INPUT2: Conditional Probabilities for the result categories for both HasGasStove=Y and HasGasStove=N	2 (Y/N)	once per profile
AC_Home	Probability of having different types of home air conditioning or ventilation	INPUT1: Fixed probabilities for the types of air conditioning / ventilation (the number of types is user-defined)	any number	once per profile
AC_Car	Probability of having A/C in car	INPUT1: Probabilities for the 2 results	2 (Y/N)	once per profile
WindowRes	Probability of residence windows being open or closed, conditional on AC_Home, MaxTempCat, and AvgTempCat	INPUT1: Type of home A/C (AC_Home) INPUT2: Max. temperature on day of simulation (MaxTemp) INPUT3: Average temperature on day of simulation (AvgTemp) INPUT4: Conditional probabilities for the result categories for every combination of input1-input3 categories	2 (Y/N)	daily
WindowCar	Probability of car windows being open	INPUT1: Has car A/C (AC_Car)	2 (Y/N)	daily

Conditional Variable	Purpose	Input Variables	Number of Categories	Function Reevaluated
	or closed, conditional on AC_Car, MaxTempCat, and AvgTempCat	INPUT2: Max. temperature on day of simulation (MaxTemp) INPUT3: Average temperature on day of simulation (AvgTemp) INPUT4: Conditional probabilities for the result categories for every combination of input1-input3 categories		
SpeedCat	Probability of average speed categories for vehicles	INPUT1: Fixed probabilities for the result categories	any number	daily
DailyConditional1	Generic daily conditional variable #1	INPUT1: Fixed probabilities for the result categories	any number	daily
DailyConditional2	Generic daily conditional variable #2	INPUT1: Fixed probabilities for the result categories	any number	daily
DailyConditional3	Generic daily conditional variable #3	INPUT1: Fixed probabilities for the result categories	any number	daily
ProfileConditional1	Generic profile conditional variable #1	INPUT1: Fixed probabilities for the result categories	any number	once per profile
ProfileConditional2	Generic profile conditional variable #2	INPUT1: Fixed probabilities for the result categories	any number	once per profile
ProfileConditiona3	Generic profile conditional variable #3	INPUT1: Fixed probabilities for the result categories	any number	once per profile
ProfileConditional4	Generic profile conditional variable #4	INPUT1: Fixed probabilities for the result categories	any number	once per profile
ProfileConditional5	Generic profile conditional variable #5	INPUT1: Fixed probabilities for the result categories	any number	once per profile
RegionalConditional1	Generic regional conditional variable #1	INPUT1: Fixed probabilities for the result categories, defined for each region (sector or county) modeled	any number	once per profile, based on profile's home sector
RegionalConditional2	Generic regional conditional variable #2	INPUT1: Fixed probabilities for the result categories, defined for each region (sector or county) modeled	any number	once per profile, based on profile's home sector
RegionalConditional3	Generic regional conditional variable #3	INPUT1: Fixed probabilities for the result categories, defined for each region (sector or county) modeled	any number	once per profile, based on profile's home sector
RegionalConditional4	Generic regional conditional variable #4	INPUT1: Fixed probabilities for the result categories, defined for each region (sector or county) modeled	any number	once per profile, based on profile's home sector
RegionalConditional5	Generic regional conditional variable #5	INPUT1: Fixed probabilities for the result categories, defined for each region (sector or county) modeled	any number	once once per profile, based on profile's home sector profile

```
AvgTempCat
! Temperature ranges (categories) in Fahrenheit
INPUT1 INTRANGE 3         "AvgTemp"
50 78
RESULT INTEGER 3          "TempCatA"
1 2 3
#
WindowRes
! Home windows open(1) or closed
INPUT1 INTVALUE 2         "AC_Home"
1 2
INPUT2 INTRANGE 3         "MaxTemp"
56 80
INPUT4 CONDITIONAL 12
0.2 0.8
0.2 0.8
0.5 0.5
0.7 0.3
0.1 0.9
0.9 0.1
RESULT INTEGER 2
1 2
#
DailyConditional3
! DailyConditional3 - Penetration values for vehicle micro
INPUT1 PROBABILITY 4
0.2 0.5 0.2 0.1
RESULT INTEGER 4
1 2 3 4
#
RegionalConditional1
! Has attached garage
BY Sector 14
INPUT1 PROBABILITY 2
01017953800 0.05  0.95
01017953900 0.05  0.95
01017954000 0.05  0.95
01017954200 0.05  0.95
01017954300 0.05  0.95
01017954400 0.05  0.95
01017954500 0.05  0.95
13013180101 0.8   0.2
13013180102 0.8   0.2
13013180201 0.8   0.2
13013180202 0.8   0.2
13013180300 0.8   0.2
13013180400 0.8   0.2
13013180500 0.8   0.2
RESULT INTEGER 2
1 2
#
```

Exhibit 4-18. Examples of Profile Functions

The third example is a definition for a user-defined conditional variable **DailyConditional3**. In this case, the user wanted to define four categories of a variable (penetration) for a given microenvironment, and assign each category a probability of being selected on a given day. All user-defined conditional variables are designated in an analogous manner. The only valid input type for the user-defined conditional variables is PROBABILITY. Note the probabilities for the four categories in the example sum to one. The resulting category number is saved to the profile on each day, and can be used to determine the microenvironment parameters (Section 4.19.2).

The final example is a function definition for a regional conditional variable **RegionalConditional1**. In this example, it is being used to describe difference in housing conditions (presence of an attached garage) in different sectors of the study area. The BY statement indicates how the prevalence vary regionally, either by county or by sector (in this case, sector). This line must additionally contain the number of regions (ie. counties or sectors) that will be used (in this case, 14). After this BY line, the probability input for each sector or county is listed. APEX matches these regions to the appropriate study area sector (or sectors, in the case of a county), and uses them when assigning the value of RegionalConditional1-5 to each profile. Counties may only be used when modeling census tracts, as the first 5 characters of the census tract is the FIPS code for the county. An APEX warning will result if a listed region does not match up with any study area sector, and APEX will fail if there exists a study area sector for which there is no corresponding region. The result of this function is that profiles in each sector will be assigned an attached garage (the RESULT,1=yes, 2=no) based on their sector's listed probabilities.

The minimum number of categories for all the variables defined in the ***Profile Functions*** file is one, in which case all profiles will have the same value for the variable. However, microenvironment parameters cannot depend on the values of variables having only one category (it wouldn't make sense because everyone is the same). In the case of all functions EXCEPT *DairyPools*, having one category is the default case and can be implemented by simply omitting the function definition from the *Profile Functions* file. *DiaryPools*, however, is required to be defined in the file. Therefore, if one wishes to define only a single diary pool, this must be done explicitly, by setting all the RESULT values for the function equal to one. For example,

```
DiaryPools
! Group activity diaries into pools
TABLE
INPUT1 INTRANGE 1       "MaxTemp"
INPUT2 INTRANGE 1       "AvgTemp"
INPUT3 INTINDEX 7       "DayOfWeek"
RESULT INTEGER 7        "Pool number"
1 1 1 1 1 1 1
```

There is no explicit upper limit on the number of categories, and in practice it is only limited by what is convenient.

4.16 Microenvironment Mapping File

This file provides the mapping of the ***Location Codes*** (e.g., for CHAD) to ***Microenvironments*** defined in APEX. The current CHAD location codes are given in Table 4-9, and an example portion of a *Microenvironment Mapping* file is provided in Exhibit 4-19. This file only allows comment lines and keyword input lines, except for the first two header lines. Each keyword input line begins with a location code followed by a short description, an "=", an integer that designates a microenvironment defined in the *Microenvironment Description* file, and a character variable that assigns the location code as belonging to a "Home", "Work", "Other", or

“Unknown” location (H/W/O/U). These designations are used to assign a set of microenvironment concentrations to each event; as three sets of concentrations are calculated in APEX based on air concentrations for the “home”, “work”, and “other” locations. (See *Volume II* for details).

The supplied file contains microenvironment assignments for the 115 CHAD location codes. The user must assign each location code to microenvironments defined in the *Microenvironment Description* file by specifying the microenvironment number in the APEX Microenvironment column. The file must contain assignments for all CHAD location codes, or APEX will exit with a Fatal error.

A zero in the APEX Microenvironment column will result in no exposure in that CHAD microenvironment location. A value of -1 means that APEX will use whichever microenvironment was previously in use in the composite diary time series for an individual (typically used for CHAD locations ‘U’ and ‘X’).

Table 4-9. CHAD Location Codes

Location Code	*Description*	*Location Code*	*Description*
X	No data	31210	Walk
U	Uncertain of correct code	31230	In stroller or carried by adult
30000	Residence- general	31300	Waiting for travel
30010	Your residence	31310	... bus or train stop
30020	Other residence	31320	... indoors
30100	Residence- indoor	31900	Travel- other
30120	Your residence- indoor	31910	... other vehicle
30121	... kitchen	32000	Non-residence indoor- general
30122	... living room or family room	32100	Office building/ bank/ post office
30123	... dining room	32200	Industrial/ factory/ warehouse
30124	... bathroom	32300	Grocery store/ convenience store
30125	... bedroom	32400	Shopping mall/ non-grocery store
30126	... study or office	32500	Bar/ night club/ bowling alley
30127	... basement	32510	Bar or night club
30128	... utility or laundry room	32520	Bowling alley
30129	... other indoor	32600	Repair shop
30130	Other residence- indoor	32610	Auto repair shop/ gas station
30131	... kitchen	32620	Other repair shop
30132	... living room or family room	32700	Indoor gym /health club
30133	... dining room	32800	Childcare facility
30134	... bathroom	32810	... house
30135	... bedroom	32820	... commercial
30136	... study or office	32900	Large public building
30137	... basement	32910	Auditorium/ arena/ concert hall
30138	... utility or laundry room	32920	Library/ courtroom/ museum/ theater
30139	... other indoor	33100	Laundromat
30200	Residence- outdoor	33200	Hospital/ medical care facility
30210	Your residence- outdoor	33300	Barber/ hair dresser/ beauty parlor
30211	... pool or spa	33400	Indoors- moving among locations
30219	... other outdoor	33500	School
30220	Other residence- outdoor	33600	Restaurant
30221	... pool or spa	33700	Church
30229	... other outdoor	33800	Hotel/ motel
30300	Residential garage or carport	33900	Dry cleaners
30310	... indoor	34100	Indoor parking garage
30320	... outdoor	34200	Laboratory
30330	Your garage or carport	34300	Indoor- none of the above
30331	... indoor	35000	Non-residence outdoor- general
30332	... outdoor	35100	Sidewalk- street
30340	Other residential garage or carport	35110	Within 10 yards of street
30341	... indoor	35200	Outdoor public parking lot /garage
30342	... outdoor	35210	... public garage
30400	Residence- none of the above	35220	... parking lot
31000	Travel- general	35300	Service station/ gas station
31100	Motorized travel	35400	Construction site
31110	Car	35500	Amusement park
31120	Truck	35600	Playground

Location Code	*Description*	*Location Code*	*Description*
31121	Truck (pickup or van)	35610	... school grounds
31122	Truck (not pickup or van)	35620	... public or park
31130	Motorcycle or moped	35700	Stadium or amphitheater
31140	Bus	35800	Park/ golf course
31150	Train or subway	35810	Park
31160	Airplane	35820	Golf course
31170	Boat	35900	Pool/ river/ lake
31171	Boat- motorized	36100	Outdoor restaurant/ picnic
31172	Boat- other	36200	Farm
31200	Non-motorized travel	36300	Outdoor- none of the above

```
! APEX4 Microenvironment Mapping File
! Mapping of CHAD activity locations to APEX microenvironments
!CHAD Loc.  Description                        Micro #    Location  Notes
---------  --------------------------------------------------------------------------------
U          Uncertain of correct code          =   -1         U      Unknown
X          No data                            =   -1         U      Unknown
30000      Residence, general                 =    1         H      Home
30010      Your residence                     =    1         H      Home
30020      Other residence                    =    1         H      Home
30100      Residence, indoor                  =    1         H      Home
30120      Your residence, indoor             =    1         H      Home
30121      ..., kitchen                       =    1         H      Home
30122      ..., living room or family room    =    1         H      Home
```

Exhibit 4-19. Example Portion of a Microenvironment Mapping File

4.17 Diary Questionnaire (DiaryQuest) File

This file provides the personal information component of each 24-hour activity diary (Exhibit 4-20). Each record contains values for the following variables:

- ***CHAD ID***
- ***Day type*** (MON, TUE, …, SUN, Missing (X))
- ***Gender*** (Male (M), Female (F), Missing (X))
- ***Race*** (White (W), Black (B), Asian (A), Hispanic (H), Other (O), not available (X))
- ***Employment status*** (Yes (Y), No (N), Missing (X))
- ***Maximum hourly temperature for this diary day*** (degrees F)
- ***Daily mean temperature for this diary day*** (degrees F)
- ***Age*** (Years)
- ***Occupation code*** (see Table 4-10)
- ***Missing time*** (the total number of minutes associated with events in the Diary Events file for which the activity and/or location codes are missing for this diary day)
- ***Record count*** (the number of records in the CHAD Diary Events file corresponding to this diary day)

The user should not change this input file unless the CHAD database has changed or other activity data are to be used instead. If the latter, the input file format restrictions must be met, the CHAD coding conventions used, and the other CHAD files modified to be consistent with this file. Note that this file has one record per CHAD ID, whereas the CHAD Diary Events file has ***Record Count*** of records per CHAD ID.

```
BAL97001A,TUE,F,W,N,      77,   43,X   ,  45,      29
BAL97001B,WED,F,W,N,      77,   51,X   , 135,      28
BAL97001C,THU,F,W,N,      77,   57,X   ,  15,      30
BAL97001D,FRI,F,W,N,      77,   45,X   ,   0,      28
BAL97001E,TUE,F,W,N,      77,   47,X   ,   0,      27
BAL97001F,WED,F,W,N,      77,   36,X   ,   0,      28
BAL97001G,THU,F,W,N,      77,   38,X   ,   0,      26
BAL97001H,FRI,F,W,N,      77,   43,X   ,   0,      28
BAL97001I,TUE,F,W,N,      77,   41,X   ,  15,      28
BAL97001J,WED,F,W,N,      77,   54,X   ,  15,      28
BAL97001K,THU,F,W,N,      77,   48,X   ,   0,      30
BAL97001L,FRI,F,W,N,      77,   42,X   ,  30,      30
BAL97006A,WED,M,W,N,      80,   51,X   ,   0,      31
BAL97006B,THU,M,W,N,      80,   57,X   ,  60,      36
BAL97006C,FRI,M,W,N,      80,   45,X   ,  75,      31
BAL97006D,TUE,M,W,N,      80,   47,X   ,  15,      33
BAL97006E,WED,M,W,N,      80,   36,X   ,  30,      31
BAL97006F,THU,M,W,N,      80,   38,X   , 210,      34
BAL97006G,FRI,M,W,N,      80,   43,X   , 165,      30
BAL97006H,TUE,M,W,N,      80,   41,X   ,  45,      31
BAL97006I,WED,M,W,N,      80,   54,X   ,  60,      34
BAL97006J,THU,M,W,N,      80,   48,X   ,  15,      31
BAL97008A,TUE,F,W,N,      88,   43,X   ,   0,      31
BAL97008B,WED,F,W,N,      88,   51,X   ,  60,      27
BAL97008C,THU,F,W,N,      88,   57,X   , 345,      33
BAL97008D,FRI,F,W,N,      88,   45,X   ,  90,      28
BAL97008E,TUE,F,W,N,      88,   47,X   ,  30,      29
BAL97008F,WED,F,W,N,      88,   36,X   ,  90,      26
```

Exhibit 4-20. Example Portion of a Diary Questionnaire File

Table 4-10. CHAD Occupation Codes

Code	**Description**
ADMIN	Executive, administrative, and managerial
PROF	Professional
TECH	Technicians
SALE	Sales
ADMSUP	Administrative support
HSHLD	Private household
PROTECT	Protective services
SERV	Service
FARM	Farming, forestry, and fishing
PREC	Precision production, craft, and repair

Code	Description
MACH	Machine operators, assemblers, and inspectors
TRANS	Transportation and material moving
LABOR	Handling, equipment cleaners, helpers, and laborers
X	Missing

4.18 Diary Events File

This file provides descriptions of events in each day for all the diary days in the CHAD database. Events may last from one minute to one hour in duration. Each record includes the following variables:

- ***CHAD ID***;
- ***Event Start Time*** (the time the event began; HHMM, with 0000 representing midnight);
- ***Event Duration*** (the duration of the event, in minutes);
- ***Activity Code*** (see Table 4-5); and
- ***Location Code*** (see Table 4-9).

This file should be generated from the CHAD database at the same time as the *Diary Questionnaire* (*DiaryQuest*) file to ensure that the CHAD IDs are in the same order. Each diary day begins and ends at midnight and there should be exactly twenty-four hours of data per diary. See Exhibit 4-21 for an example of a portion of this file. See the previous section on the *Diary Questionnaire* file if user-supplied data are to be provided.

```
BAL97001A,0000,60,14500,30125,
BAL97001A,0100,60,14500,30125,
BAL97001A,0200,60,14500,30125,
BAL97001A,0300,60,14500,30125,
BAL97001A,0400,60,14500,30125,
BAL97001A,0500,60,14500,30125,
BAL97001A,0600,60,14500,30125,
BAL97001A,0700,30,14500,30125,
BAL97001A,0730,30,14400,30121,
BAL97001A,0800,60,16000,30122,
BAL97001A,0900,60,14500,30125,
BAL97001A,1000,30,14500,30125,
BAL97001A,1030,30,X    ,X    ,
BAL97001A,1100,45,14500,30125,
BAL97001A,1145,15,X    ,X    ,
BAL97001A,1200,60,14500,30125,
BAL97001A,1300,60,14500,30125,
BAL97001A,1400,60,14500,30125,
BAL97001A,1500,60,16000,30122,
BAL97001A,1600,60,14600,30125,
BAL97001A,1700,15,14600,30125,
BAL97001A,1715,45,14400,30123,
BAL97001A,1800,45,14400,30123,
```

Exhibit 4-21. Example Portion of Diary Events File

4.19 Diary Statistics File

This file contains a diary statistic for each diary in the CHAD database. This file is used in constructing multi-day (longitudinal) diaries in APEX from the CHAD one-day diaries. Refer to Volume II for information on how to construct this file.

APEX has two options for assembling simulation-length diaries. The first method is to randomly pick a new day-long diary from CHAD for each day in the simulation. However, APEX also contains a longitudinal diary assembly algorithm for selecting diaries based on some key statistic of each CHAD diary. Details of this longitudinal diary algorithm are provided in *Volume II: Technical Support Document*. In short, the algorithm requires the selection of a diary based on some key diary statistic relevant to the pollutant being studied. For example, the statistic may be time spent outdoors or time spent in a vehicle.

The *Diary Stati*stics file must contain the CHAD ID for each diary and the value of this statistic (ID and statistic separated by a comma or a space, one diary per row). The order of the CHAD IDs in this file must be the same as on the *Diary Questionnaire (DiaryQuest)* file, or an error will result.

Two *Diary Statistics* files have been generated from CHAD and are included in the APEX Version 4 release. These files are for time spent outdoors and time spent in vehicles. The files were constructed by summing the time spent in locations considered “outdoors” or “in vehicle” in each CHAD diary. Table 4-11 gives the CHAD location codes that were used to generate these files. Users may construct other files from the CHAD database. An example portion of a diary statistic file is shown in Exhibit 4-22.

The use of the longitudinal algorithm is invoked by setting the Simulation Control file keyword **LongitDiary** = YES. If **LongitDiary**=NO, the *Diary Statistics* file is not needed, and need not be specified in the *Control* file.

Table 4-11. Chad Locations Used in Constructing the Outdoor Time and Vehicle Time Diary Statistics Files

CHAD Location IDs Considered “Outdoors”	CHAD Location IDs Considered “In Vehicle”
30332, 30342, 30320, 30200, 31310, 35000-36300	31000-31172

```
! CHAD Longitudinal Activity Statistics File for Time Outdoors
! (CHAD locations 30332,30342,30320,30200,31310,35000-36300)
! Prepared by Alion Science & Technology, Inc. for EPA
! Created 6/24/05
! CHAD ID, time spent outdoors (minutes)
BAL97001A,  45
BAL97001B, 180
BAL97001C,   0
BAL97006A,  75
BAL97006B, 270
BAL97006C, 135
BAL97006D,  75
BAL97006E,  30
BAL97006F, 270
BAL97006G, 135
BAL97006H, 150
BAL97006I,  90
BAL97006J,  90
```

Exhibit 4-22. Example Part of a Diary Statistics File

4.20 Microenvironment Descriptions File

The *Microenvironment Descriptions* input file serves two purposes. Firstly, it defines the methods by which pollutant concentrations are calculated in each microenvironment. Secondly, it tells APEX how to define the parameters that are required to calculate these concentrations. The parameters are defined for each microenvironment for each pollutant (with the exception of the parameters air exchange rate and microenvironment volume, which are not pollutant-specific). Thus, the *Microenvironment Descriptions* file has two sections following the general header records: Microenvironment Descriptions and Parameter Descriptions. An example of the Microenvironment Description section is shown in Exhibit 4-23 while an example Parameter Description section is shown in Exhibit 4-24. The examples shown in these figures will be discussed in detail below.

4.20.1 Microenvironment Descriptions Section

In the Microenvironment Descriptions section of the *Microenvironment Descriptions* file, the user specifies a ***Microenvironment Number***, a ***Name***, and a ***Calculation Method*** for each microenvironment, as shown in Exhibit 4-23. The microenvironment number cannot exceed the number of microenvironments specified in the *Control* file, nor can it exceed 127. It also has to correspond with each of the microenvironment numbers in the *Microenvironment Mapping* file. A microenvironment name may be a word up to 40 characters. The calculation method could be either MASSBAL or FACTORS. In the MASSBAL method, the concentration in a microenvironment is calculated using a mass balance approach, while in the FACTORS method the microenvironment concentration is assumed to be a linear function of ambient concentration. See *Volume II: Technical Support Document* for further description of the MASSBAL and FACTORS methods.

```
Micro               Name           Method
1                        Residence      MASSBAL
2                        Car            MASSBAL
3                        InsideOther    FACTORS
4                        Outside        FACTORS
```

Exhibit 4-23. Example Microenvironment Descriptions Section of the Microenvironment Descriptions File

4.20.2 Parameter Descriptions Section

The Parameter Descriptions section of the *Microenvironment Descriptions* file consists of the specification of probability distributions for the microenvironmental parameters that are required for calculating pollutant concentrations in the microenvironments. See *Volume II: Technical Support Document* for further information on the microenvironmental parameters required for the MASSBAL and FACTORS concentration calculation methods. Three microenvironmental parameters can be defined for the FACTORS method and eight microenvironmental parameters can be defined for the MASSBAL method. In each method, some of the microenvironmental parameters can take on default values, and thus need not be explicitly defined. The parameters and their default values (if present) are given in Table 4-12. Air exchange rate and volume are not pollutant-specific, so they are only defined once. Otherwise, there must be one definition for each microenvironmental parameter for each pollutant for each microenvironment, with the exception of the two pollutant source types (CSource and ESource) which permit multiple sources in the same microenvironment.

Table 4-12. Microenvironment Parameters For the FACTORS and MASSBAL Methods

Calculation method	Parameter type	Code	Units	Default value
FACTORS	Proximity	PR	None	1
	Penetration	PE	None	1
	Csource	CS	ppm or μg/m^3 (depends on InputUnits)	0
MASSBAL	Proximity	PR	None	1
	Penetration	PE	None	1
	Decay Rate	DE	1/hr	0
	Air Exchange Rate	AE	1/hr	none
	Volume	VO	m^3	none
	MeanR	MR	1/hr	AirExRate+DecayRate
	Csource	CS	ppm or μg/m^3 (depends on InputUnits)	0
	ESource	ES	μg/hr	0

As mentioned above, not all of the parameters must be explicitly defined for each microenvironment. If the default values in Table 4-12 are acceptable for a microenvironment, then a given parameter definition may be omitted from the input file. For FACTORS, default values exist for all the parameters. If no parameters are defined for microenvironments using the FACTORS method, then the microenvironment concentration is always equal to the current ambient concentration. For a MASSBAL microenvironment, the air exchange rate parameter must always be defined as it has no default value. The volume parameter does not have a default either, but it is only used if ESource terms exist for that microenvironment and may be omitted otherwise. All other parameters are optional. The proximity and penetration factors are used to model the ambient pollutant concentrations immediately outside and inside a microenvironment. The air exchange rate and volume variables define the air flow rate in and out of the microenvironment and the microenvironment air volume. The decay rate defines the rate of removal of pollutant from the microenvironment via various means. The parameter MeanR is a factor that describes the removal of pollutant by both air flow and decay. The CSource and Esource terms are concentration and emission pollutant sources, respectively. See *Volume II* for a detailed description of these parameters and the microenvironmental concentration equations.

As part of the estimation of microenvironment concentrations, each microenvironmental parameter for each pollutant is given a value for each hour of the simulation, for each profile generated. This value may or may not be different from the values at other hours, depending on choices in the microenvironmental parameters definition. Some microenvironmental parameters, such as house volume, typically remain constant throughout the simulation, while others may change seasonally, daily, or hourly. Values may recur in patterns, such as the same set of 24 hourly values for some parameter may recur each Saturday in the Winter season. These patterns are determined from the four mapping options and the three resampling options specified in each microenvironmental parameter definition.

The definitions for the microenvironment parameters may appear in any order in the *Microenvironment Descriptions* file. Therefore, the user (for example) may choose to group definitions by microenvironment or by pollutant. Each definition should be separated from the next either by blank lines or by comment lines (starting with an exclamation point) to aid in clarity. A parameter description consists of **keywords** and **distribution definitions**, described in the following sections.

Keywords

The first part of a microenvironment parameter description is a list of settings, each described by a keyword. The different keywords have a number of purposes, including specifying:

- Which microenvironment is being considered
- Which pollutant is being considered (not needed for air exchange rate or volume)
- Which parameter is being defined for that microenvironment (the parameter **Code**)
- The source number for the current parameter (if it is ESource or CSource)
- How that parameter varies over hours in the day, days of the week, or months of the year
- Whether the parameter depends on any conditional variables

- Whether the parameter is correlated with any other parameter (by being sampled using the same random numbers)
- A random number seed for generating the parameter values
- Whether or not a new value of parameter is generated for each hour, for each day, and for the workplace

The keywords and their descriptions are provided in Table 4-13.

The conditional variable keywords must be either one of the conditional variables listed in Table 4-8 (**TempCat, HumidCat, WindCat, DirCat, PrecipCat, MaxTempCat, AvgTempCat, HasGasStove, HasGasPilot, AC_Home, AC_Car, WindowRes, WindowCar, SpeedCat, DailyConditional1-DailyConditional3, ProfileConditional1-ProfileConditional5, RegionalConditional1-RegionalConditional5**), or **Gender**, **Employed**, or **PopCat**. All variables, with the exception of the last three, must be defined in the *Profile Functions* file in order to be used as a conditional variable in a microenvironmental parameter description. **PopCat** is the "population category," or gender/race combination (for example, "white males" is a population category). Therefore, **Gender** and **PopCat** should not both be used as conditional variables for the same microenvironmental parameter.

In APEX the user has the option of correlating samples for microenvironmental parameters. Such correlation would make sense, for example, when the value of the parameter is assumed to be mainly a function of the properties of a simulated individual's home and the pollutants have similar properties (for example, are all particles). In addition, in some cases it may be that the same parameters may be correlated in different microenvironments. APEX uses a simple method of correlation microparameters - by sampling them using the same random numbers. This results in values being selected for correlated parameters at the same percentile from the appropriate distributions. The percentiles will correspond each hour as long as the 2 (or more) parameters use the ***same conditional variables, time and area mappings, and resampling rates*** and thus have the same number of required distributions and samples. Otherwise the samples get out of phase and any correlation is lost. APEX checks that the conditionals, mappings, and resampling are the same when correlating parameters, and writes a warning if they are not. APEX will still run, but the user should be aware that the correlation is lost.

Correlation is handled by an optional keyword in the microparameter definition, CORRNUM. Each subset of microparameters that the user desires be correlated (sampled at the same percentile each hour) are assigned a unique integer 1-N, where N is the total number of correlated subsets.

All the keywords for the microenvironmental parameter come at the beginning of the microenvironmental parameter definition. After the definition of all the keywords, the next line should be the header line for the data section (that is, the section that contains the actual distribution definitions for the microenvironmental parameter). The header line must begin with the word ***Block***, as APEX recognizes this word as indicating the end of the keyword section. (See Exhibit 4-24 for an example of an appropriate header.)

Table 4-13. Keyword Definitions for the Parameter Descriptions Section of the Microenvironment Descriptions File

Keyword	Description
Microenvironment Number	These numbers must match the microenvironment numbers in the Microenvironment Descriptions section.
Pollutant	Integer corresponding to the pollutant being considered. (Number corresponds to the order of the pollutant definition in the *Control* file). **Not needed for AER and Volume definitions (ignored if defined).**
Parameter Type	A parameter code such as PR (Proximity) and PE (Penetration) provided in Table 5-8 should be used to specify a parameter type.
Correlation Number	Integer number corresponding to correlation subset. Each subset of microparameters that the user desires be correlated (sampled at the same percentile each hour) are assigned a unique integer 1-N, where N is the total number of correlated subsets.
Source Number	Numbers multiple sources in the same microenvironment. Not needed if there is only one source present.
Hours - Block	This variable is used to map hours of a day to different time blocks. A "time block" is a group of hours for which the same microenvironmental parameter distribution(s) will be used. The input line always contains a list of 24 integers, representing 24 hours a day. The first hour is midnight to 1 a.m. and the 24th is 11 p.m. to midnight. The position of an integer in the input line represents the hour in a day. The integer represents the number of a time block that an hour belongs to. The hours in a time block do not need to be consecutive, nor does a time block have to have the same number of hours. If this line is missing, the default value is that all 24 hours are in a single time block - block #1.
Weekday - Daytype	This variable is used to map days in a week to different day types. A "day type" is a set of days for which the same microenvironmental parameter distribution(s) will be used. Seven integers must be given in this input line. The position of an integer in the input line represents a day, beginning on Sunday and ending on Saturday. The integer represents the day type a day belongs to. If this variable is not defined, all days of a week will belong to day type #1.
Month - Season	This variable is used to map months of a year to different seasons. A "season" is a set of months for which the same microenvironmental parameter distribution(s) will be used. Twelve integers must be given in this input line. The position of an integer represents a month of a year, beginning in January and ending in December. The integer represents the season that a month belongs to. If this line is missing, all 12 months belong to season #1.
District - Area	This variable is used to map air districts to larger areas. The number of integers in this line must match the number of air districts in the study area. This variable is a holdover from APEX2 and should not be used unless really necessary. The user could delete this line or place the same number of 1 in this line as the number of air districts.

Keyword	Description
Condition # 1	Choice for the first conditional variable. A conditional variable is a variable whose value affects the choice of microenvironmental parameter distribution(s). If not used, this line may either be omitted or the value set to zero.
Condition # 2	Choice for the second conditional variable.
Condition # 3	Choice for the third conditional variable.
ResampHours	Either YES or NO. If YES, a random value is selected from distribution for a parameter in each hour within a time block. If NO, a random value is selected for a parameter for a time block and used for every hour within the time block. The default value is NO.
ResampDays	Either YES or NO. If YES, a random value is selected from a distribution for a parameter for each day within a day type. If NO, a random value is selected for a day type and used for every day within the same day type. The default is NO.
ResampWork	Either YES or NO. If YES, a separate set of random values is selected from a distribution for the workplace. If NO, the same set of random values are used (for the same day and hour) both for home and at work. The default is YES.
RandomSeed	Either zero or a positive integer up to about 2.1 billion. If zero, the random number seed for a parameter is determined from the internal clock, and the results will differ from one run to another. If not zero, then Seed = (RandomSeed x 232) + RandomSeed. Multiple model runs with the same seed will generate the same sequence of random numbers for the parameters (as long as the microenvironmental parameter definition is unchanged). The default value is zero.

Distribution Definitions

The last part of a microenvironmental parameter definition lists the probability distributions for the microenvironment parameter at different times or under different circumstances during the simulation. Sets of distribution data may exist for all possible combinations of the user-specified cases of the following seven indexing variables:

- ***Block*** — time block (as described by the Hours –Block mapping in the keyword section)
- ***Daytype*** — day type (as described by the Weekday – Daytype mapping in the keyword section)
- ***Season*** — season of the year (as described by the Month – Season mapping in the keyword section)
- ***Area*** — air quality area (as described by the District – Area mapping in the keyword section
- ***C1*** — conditional variable # 1
- ***C2*** — conditional variable # 2
- ***C3*** — conditional variable # 3

These variables are listed in the header line for the data section. The indices for each of the above variables should be noted under their appropriate columns in the header. Then the parameter distributions must be listed one per line, looping over the variables in the order of the above list. Note that the cases of each indexing parameter must be represented by integers ranging from 1 to the maximum number of cases for an indexing variable.

The number of cases for the indexing variables **Block**, **Daytype**, and **Season** are specified by mappings in the keyword section. For example, the number of time blocks would be the highest integer indicated in the **Time-Block** mapping. For the conditional variables **MaxTempCat, AvgTempCat, HasGasStove, HasGasPilot, AC_Home, AC_Car, WindowRes, WindowCar, SpeedCat, DailyConditional1-DailyConditional3, ProfileConditional1-ProfileConditional5, or RegionalConditional1-RegionalConditional5** the number of cases is determined by the number of **Results** indicated on the *Profile Functions* file (Section 4.15). For **Gender**, there are always 2 cases. For **PopCat**, the number of cases is indicated by the number of population groups (population files) defined on the *Control* file (Section 4.2), and the groups are indexed in the order they appear in the file (for example, if the population file for white females happened to be defined first in the *Control* file, then that group would correspond to the case **PopCat**=1).

The user specifies the microparameter distribution using the standard APEX distribution format (a distribution shape, followed by 4 distribution parameters, upper and lower truncation bounds, and a resampling flag). The 4 parameters used are dependent on the shape of the distribution. See *Volume II* for a complete discussion of the use of probability distributions in APEX. Thus the following data must be present in each specification:

- ***Distribution Shape***. This variable gives the type of the distribution
- ***Par1.*** Parameter 1 of the microparameter distribution. Depends on shape.
- ***Par2***. Parameter 2 of the microparameter distribution. Depends on shape.
- ***Par3.*** Parameter 3 of the microparameter distribution. Depends on shape.
- ***Par4.*** Parameter 4 of the microparameter distribution. Depends on shape.
- ***LTrunc***. Lower truncation point of the distribution.
- ***UTrunc***. Upper truncation point of the distribution.
- ***ResampOut.*** Distribution resampling flag.

See Table 4-6 for the available distribution shapes and required parameters. The parameters that are not used for specifying a distribution should be marked with a period (".").

Example Parameter Descriptions

Two examples of parameter descriptions are shown in Exhibit 4-24. These examples should provide the user with a good idea of how the keywords and distribution definitions work.

In the first example, the microenvironment parameter Air Exchange Rate (**AE**) is defined for Microenvironment #1. In this case, the parameter distribution is only a function of two conditional variables, **AvgTempCat**, and **AC_Home**. The parameter is not resampled from the distribution every hour (**ResampHours**=NO) nor each day (**ResampDays**=NO), although the parameter is resampled if the simulated person moves between home and work (**ResampWork**=YES). In this case the conditional variable **AvgTempCat** has five possible values (1-5) and **AC_Home** has two possible values (1-2); these variables and their values were defined in the *Profile Functions* file. Thus, probability distributions for **AE** must be defined at all 10 combinations of the two conditional variables. The ten distributions are lognormal in shape (although they have different parameters), and are listed in order – first looping over the values of **AvgTempCat** and then **AC_Home**.

In the second example, Penetration Factor (**PE**) is defined for Microenvironment #12. Here, the distributions are not a function of any conditional variable, but rather different time blocks, day types, and seasons. Distributions for **PE** must be defined for all possible combinations of these time variables. The **Hour-Block** keyword line indicates a mapping of the hours of the day into two different time blocks (1 and 2) roughly defining night and day. Thus a different parameter distribution for **PE** will be used for these two time blocks. Similarly, the **Weekday–Daytype** mapping keyword line defines two different day types, "1" for Saturday and Sunday, and "2" for the rest of the days of the week. Finally, the **Month-Season** mapping keyword line defines four seasons, labeled 1-4, corresponding to winter, spring, summer, and autumn. The distributions follow (again looping first over block, then day type, then season), and in this example the parameter is defined as a single point value in all cases.

It is clear that these methods allow the user a great deal of flexibility in defining different distributions for the microenvironmental parameters. In most cases, many of the features of these descriptions will not be used, but in some cases the user may wish to define a large number of distributions for a single parameter. There is no limit in APEX on the number of distributions that can be defined for a microenvironment parameter.

```
Micro number      = 1
Parameter Type    = AE
Condition # 1     = AvgTempCat
Condition # 2     = ACHome
ResampHours       = NO
ResampDays        = NO
ResampWork        = YES
Block DType Season Area  C1  C2  C3   Shape      Par1   Par2  Par3 Par4  LTrunc UTrunc  ResampOut
1     1     1      1     1   1   1   Lognormal   0.95    1.7   0    .     0.111  10.0   Y
1     1     1      1     2   1   1   Lognormal   0.65    1.7   0    .     0.111  10.0   Y
1     1     1      1     3   1   1   Lognormal   0.35    1.7   0    .     0.111  10.0   Y
1     1     1      1     4   1   1   Lognormal   0.33    1.9   0    .     0.111  10.0   Y
1     1     1      1     5   1   1   Lognormal   0.33    1.9   0    .     0.111  10.0   Y
1     1     1      1     1   2   1   Lognormal   0.50    2.0   0    .     0.111  10.0   Y
1     1     1      1     2   2   1   Lognormal   0.50    2.0   0    .     0.111  10.0   Y
1     1     1      1     3   2   1   Lognormal   0.60    2.0   0    .     0.111  10.0   Y
1     1     1      1     4   2   1   Lognormal   0.80    2.0   0    .     0.111  10.0   Y
1     1     1      1     5   2   1   Lognormal   1.00    2.0   0    .     0.111  10.0   Y


Micro number      = 12
Pollutant = 3
Parameter Type    = PE
Hours - Block     = 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 1 1 1 1 1
Weekday-DayType   = 1 2 2 2 2 2 1
Month-Season   = 1 1 2 2 2 3 3 3 4 4 4 1
Block DType Season Area  C1  C2  C3   Shape      Par1   Par2  Par3 Par4  LTrunc UTrunc  ResampOut
1     1     1      1     1   1   1   Point       1.0      .     .    .     .      .       .
2     1     1      1     1   1   1   Point       0.5      .     .    .     .      .       .
1     2     1      1     1   1   1   Point       0.9      .     .    .     .      .       .
2     2     1      1     1   1   1   Point       0.4      .     .    .     .      .       .
1     1     2      1     1   1   1   Point       0.8      .     .    .     .      .       .
2     1     2      1     1   1   1   Point       0.3      .     .    .     .      .       .
1     2     2      1     1   1   1   Point       1.0      .     .    .     .      .       .
2     2     2      1     1   1   1   Point       0.9      .     .    .     .      .       .
1     1     3      1     1   1   1   Point       0.8      .     .    .     .      .       .
2     1     3      1     1   1   1   Point       0.7      .     .    .     .      .       .
1     2     3      1     1   1   1   Point       0.6      .     .    .     .      .       .
2     2     3      1     1   1   1   Point       0.5      .     .    .     .      .       .
1     1     4      1     1   1   1   Point       0.5      .     .    .     .      .       .
2     1     4      1     1   1   1   Point       0.3      .     .    .     .      .       .
1     2     4      1     1   1   1   Point       0.2      .     .    .     .      .       .
2     2     4      1     1   1   1   Point       0.1      .     .    .     .      .       .
```

Exhibit 4-24. Example Parameter Descriptions in the Microenvironment Description File

4.21 Prevalence File

The *Prevalence* file is an optional APEX input file for modeling a subpopulation of persons with a particular disease or condition. The Prevalence file is only required when the setting ***Disease*** is set in the *Control* file. APEX uses the prevalence rates to assign a YES/NO value to a physiological profile variable, **Ill**, and to produce output exposure summary tables for persons with **Ill**=YES. If ***Disease*** is not set in the control file, then the *Prevalence* file is not required and no summary tables for ill persons will be printed.

The prevalence file must contain prevalence rates (probabilities) for all age and gender cohorts from ages 0-100. Each line of the prevalence file contains an age, followed by the values for males, then females. The values in the prevalence file may be separated by one or more spaces. The age value in the file is not actually used (although it must be present); it is assumed that the values are given in age order in 1-year increments from 0 to 100. A portion of an example *Prevalence* file is shown in Exhibit 4-25.

```
! Asthma Prevalence Rates
!Age  Male   Female
 0    0.041  0.034
 1    0.070  0.052
 2    0.102  0.071
 3    0.129  0.088
 4    0.144  0.099
 5    0.164  0.119
```

Exhibit 4-25. Portion of an Example Prevalence File

CHAPTER 5. APEX OUTPUT FILES

APEX produces the following output files:

- *Log* File
- *Hourly* File
- *Daily* File
- *Profile Summary (Persons)* File
- *Microenvironmental Summary* File
- *Microenvironmental Results* File
- *Output Tables* File
- *Sites* File
- *Events* File

These are all ASCII files which can be opened and reviewed using a text editor or other software (e.g., spreadsheet, database, statistical analysis, and graphics). A brief summary of these files is given in Table 5-1. Details of each file are provided in Sections 5.1 to 5.12 below.

All output files contain the same set of header records, allowing files generated from the same run to be identified, and for audit trail requirements. This header section consists of six lines followed by a blank line. The contents are:

Line 1:	Type of output file
Line 2:	APEX version, date and time of start of run
Line 3:	Location description (from *Control* file)
Line 4:	Scenario description (from *Control* file)
Line 5:	Echoes first line of *Control* file
Line 6:	List of the Pollutants (as given in *Control* file)
Next N Lines:	Echo the first line of the each of the *Air Quality Data* files for the N pollutants in the simulation. If the output file is pollutant-specific, then only the line from its corresponding *Air Quality* file is echoed.

The Location, Pollutant, and Scenario descriptions echo what the user provided for those keywords in the *Simulation Control* file. In the first line of the *Control* file the user typically gives general identifying information for the simulation. Similarly, the first lines of the *Air District Data* files can identify the contents of the files.

Table 5-1. APEX Output Files.

Output file	Description
Log File	The *Log* file contains the record of the APEX model simulation as it progresses. If the simulation completes successfully, the log file indicates the input files and parameter settings used for the simulation and reports on a number of different factors. If the simulation ends prematurely, the log file contains error messages describing the critical errors that caused the simulation to end.
Hourly File	The *Hourly* file provides an hour-by-hour time series of exposures, doses, and other variables for each modeled profile.
Daily File	The *Daily* file provides a day-by-day time series of exposures, doses, and other variables for each modeled profile.
Profile Summary File	The *Profile Summary* file provides a summary of each profile modeled in the simulation. Each line lists the person's age, gender and race, in addition to a number of other personal profile variables that the model uses to simulate exposure.
Microenvironment Summary File	The *Microenvironment Summary* file provides a summary of the time and exposure by microenvironment for each profile modeled in the simulation.
Output Tables File	The *Output Tables* file contains a series of tables summarizing the exposure (and dose, if calculated) results of the simulation for a pollutant. The percentiles and exposure/dose cut-off points used in these tables are defined in the *Control* file. A *Tables* file is generated for each pollutant.
Sites File	The *Sites* file lists the sectors, air districts, and zones in the study area, and identifies the mapping between them.
Events File	The *Events* file contains event-level information (including MET, exposure, ventilation, and dose) for individuals in the simulation. Settings in the *Control* file allow the user to write this information for all persons, every Nth person, or for a set of specified profile IDs.
Microenvironment Results File	The *Microenvironment Results* file provides an hour-by-hour time series of microenvironment concentrations and parameters for a pollutant for each modeled profile for each location ("Home", "Work", and "Other"). A *Microenvironment Results* file is generated for each pollutant.

5.1 Log File

The *Log* file records the following information as a model run progresses:

- Input files used;
- Model parameters used;
- Number of diaries available to match each simulated person (or profile);
- Model execution time;
- Sectors in the study area;
- Air districts in the study area;
- Meteorology zones in the study area:
- Mappings of sectors to air districts and meteorology zones;
- Statistical summaries of each simulated person (profile); and
- Output summary tables.

If a model run stops abnormally, an error message will be written to the log file. The user should review the Log file after a model run to ensure that the simulation executed and terminated normally and that the output results are valid. Note that output summary tables in this file are exactly the same as the tables in the *Output Table* file. The level of detail of the information written to the Log file is controlled by the *Control* file setting ***DebugLevel***. ***DebugLevel*** can have a value of 1, 2, or 3; the higher the level, the more information is written to the log. The *Control* file settings ***LogDistrict***, ***LogPopulation***, ***LogProfiles***, ***LogSectors***, ***LogTables***, and ***LogZones*** also control the writing of information to the Log file. See Table 4-4 for more information on these settings.

5.2 Hourly File

The *Hourly* file contains hourly time series of a number of APEX variables, including concentrations and doses, for each simulated person or profile. **Note: if the APEX timestep is greater than 1 hour (TimeStepsPerDay<24), the *Hourly* file will not be written**. In this case the *Timestep* file (see next section) provides the best summary of the exposure and dose time series. The user can control which variables are written to the *Hourly* file via a list of keywords using the *Control* file keyword ***HourlyList***. The variables and their corresponding keywords are given in Table 5-2.

Table 5-2. APEX Variables Written to the Hourly Output File

Variable	Description	Control File Keyword	Optional
Person	Simulated profile number	-	N
Hour	Hour # of the simulation	-	N
Ve	Ventilation	VE	Y
Va	Alveolar ventilation	VA	Y

Variable	Description	Control File Keyword	Optional
EVR	Equivalent ventilation rate, Ve divided by body surface area	EVR	Y
MET	Metabolic equivalents. Time-averaged multiple of basal energy expenditure for the hour.	METS	Y
EE	Energy expenditure,	EE	Y
Micro Time	Time spent in microenvironment N (minutes)	TIME1 - TIMEN	Y
Micro Exposure	Exposure in microenvironment N	EXP1 – EXPN	Y
Ambient Concentration	Ambient pollutant concentration, time averaged over events	AMB	Y
Exposure	Time-averaged exposure for the hour	EXP	Y
Dose	Time-averaged dose for the hour. Units of dose depend on pollutant, see *Volume II.*	DOSE	Y
Intake Dose	**PM pollutants only.** Average mass inhaled per minute (includes mass not deposited) during the hour (ug/min)	INTAKEDOSE	Y
Deposited Dose	**PM pollutants only**. Total mass deposited in the respiratory system during the hour (ug).	DEPDOSE	Y
Exposure Factor	The ratio of the hourly exposure to the hourly ambient concentration	EF	Y

See *Volume II: Technical Support Document* for a description of the APEX ventilation algorithms and further information on Ve, Va, EVR, and EE. Ve, Va, EVR, MET, EE, Exposure, dose, and ambient concentration are the time-weighted averages of the event values for these variables. The ambient concentration is time-averaged over the events because the simulated individual may move between home/work/other locations (and thus possibly between air districts) in the course of an hour. Thus, the hourly ambient concentration may not be equal to the home district AQ data for that hour.

The hourly exposure in microenvironment N is the portion of the total exposure for the hour occurring in microenvironment N, equal to:

$$\text{ExpN} = \frac{\sum ConcN * Duration}{60}, \text{ for events in the hour in microenvironment N}$$

where ConcN is the concentration in microenvironment N for the event and Duration is the event duration in minutes. A weighted average is used because it is possible for concentrations in a given microenvironment to vary as the person moves between home/work/other locations during the hour. The sum of all ExpN for the hour will be identical to the total hourly exposure. Hourly exposure factor EF is just the ratio of the hourly exposure to the hourly ambient value.

The variables may be listed in any order in the control file using the keyword ***HourlyList***, but they are printed in the output file in the order they appear in the table. The list should be on a single line and may be comma or space-delimited. The EXP, DOSE, EXPN, AMB, and EF keywords control the writing of that variable for all pollutants in the simulation; the file headers for these variables will contain the pollutant name. However, the dose variables will not be written for a pollutant if it has ***DoDose***=NO in the *Control* file, even if a dose keyword is included in the ***HourlyList***.

An example use of the **HourlyList** keyword would be:

```
HourlyList     = TIME4, TIME12 EXP, EF, AMB
```

An example portion of the resulting *Hourly* file for an example two-pollutant run (Pol1 and Pol2) is shown in Exhibit 5-1.

```
APEX Hourly File
APEX Version 4.0 (dated February 19, 2007)  Run Date = 20070321  Time = 101001
Location    = Description of Location of the Study Area
Scenario    = APEX4 Sensitivity Simulation
Simulation  = ! APEX4 Sensitivity Simulation
Pollutant   = Pol1 Pol2
Air Quality = ! Hourly Pol1 air quality data for an example metropolitan area
Air Quality = ! Hourly Pol2 air quality data for an example metropolitan area
      P    Hour  Time_4 Time_12   Amb-Pol1   Exp-Pol1  EF-Pol1   Amb-Pol2  Exp-Pol2   EF-Pol2
      1      1      60       0  1.039E-02  5.842E-03    0.562  1.132E-02  6.351E-03    0.561
      1      2      60       0  9.000E-03  3.295E-03    0.366  9.000E-03  3.351E-03    0.372
      1      3      60       0  7.000E-03  2.710E-03    0.387  7.000E-03  2.756E-03    0.394
      1      4      60       0  2.000E-03  9.189E-04    0.459  2.000E-03  9.379E-04    0.469
      1      5      25       0  7.000E-03  2.297E-03    0.328  7.000E-03  2.333E-03    0.333
      1      6      26       0  2.300E-02  8.118E-03    0.353  2.300E-02  8.241E-03    0.358
      1      7      60       0  2.100E-02  7.262E-03    0.346  2.100E-02  7.392E-03    0.352
      1      8      60       0  1.800E-02  6.180E-03    0.343  1.800E-02  6.291E-03    0.349
      1      9      30       0  1.800E-02  7.378E-03    0.410  1.800E-02  7.491E-03    0.416
      1     10      12      30  1.900E-02  6.683E-03    0.352  1.900E-02  6.799E-03    0.358
      1     11      60       0  2.026E-02  8.227E-03    0.406  2.044E-02  8.427E-03    0.412
      1     12       4      15  2.400E-02  8.700E-03    0.363  2.400E-02  8.846E-03    0.369
      1     13      60       0  2.271E-02  1.138E-02    0.501  2.334E-02  1.183E-02    0.507
      1     14      60       0  3.000E-02  1.170E-02    0.390  3.000E-02  1.189E-02    0.396
```

Exhibit 5-1. Example Portion of an APEX Hourly Output File

Note that the hourly file could be very large if a large number of profiles are simulated. The user may block generation of the hourly file by setting the ***HourlyOut*** parameter to NO in the *Control* file.

5.3 Timestep File

The *Timestep* file contains the timestep-level time series of a number of APEX variables, including exposure and doses, for each simulated person or profile. The user can control which variables are written to the *Timestep* file via a list of keywords using the *Control* file keyword ***TimeStepList***. The variables and their corresponding keywords are given in Table 5-3.

Table 5-3. APEX Variables Written to the Timestep Output File

Variable	Description	Control File Keyword	Optional
Person	Simulated profile number	-	N
Hour	Hour # of the simulation	-	N
Timestep	Timestep # of the simulation	-	N
Ve	Ventilation	VE	Y
Va	Alveolar ventilation	VA	Y
EVR	Equivalent ventilation rate, Ve divided by body surface area	EVR	Y
MET	Metabolic equivalents. Time-averaged multiple of basal energy expenditure for the timestep.	METS	Y
EE	Energy expenditure,	EE	Y
Ambient Concentration	Ambient pollutant concentration, time-averaged over events in the timestep	AMB	Y
Exposure	Exposure, time-averaged over events in the timestep	EXP	Y
Dose	Time-averaged dose for the hour. Units of dose depend on pollutant, see *Volume II*.	DOSE	Y
Intake Dose	**PM pollutants only.** Average mass inhaled per minute (includes mass not deposited) during the timestep (ug/min)	INTAKEDOSE	Y
Deposited Dose	**PM pollutants only**. Total mass deposited in the respiratory system during the timestep (ug).	DEPDOSE	Y
Exposure Factor	The ratio of the timestep exposure to the timestep ambient concentration	EF	Y

See *Volume II: Technical Support Document* for a description of the APEX ventilation algorithms and further information on Ve, Va, EVR, and EE. Ve, Va, EVR, MET, EE, Exposure, dose, and ambient concentration are the time-weighted averages of the event values for these variables. The ambient concentration is time-averaged over the events because the simulated individual may move between home/work/other locations (and thus possibly between air districts) in the course of an timestep. Thus, the timestep ambient concentration may not be equal to the home district AQ data for that timestep.

The variables may be listed in any order in the control file using the keyword ***TimestepList***, but they are printed in the output file in the order they appear in the table. The list should be on a single line and may be comma or space-delimited. The EXP, DOSE, AMB, and EF keywords control the writing of that variable for all pollutants in the simulation; the file headers for these variables will contain the pollutant name. However, the dose variables will not be written for a pollutant if it has ***DoDose***=NO in the *Control* file, even if a dose keyword is included in the ***TimestepList***.

An example use of the **TimestepList** keyword would be:

```
TimestepList     = VE AMB EXP
```

An example portion of the resulting *Timestep* file for an example one-pollutant run (Pol1 and Pol2) is shown in Exhibit 5-2.

```
APEX Timestep File
APEX Version 4.0 (dated February 21, 2008)  Run Date = 20080227  Time = 111351
Location    = Description of Location of the Study Area
Scenario    = APEX4 Sensitivity Simulation
Simulation  = ! APEX4 Sensitivity Simulation
Pollutant   = ozone
Air Quality = Name =0000200006

      P    Hour Timestep      Ve  Amb-ozone  Exp-ozone
      1       1        1   4858. 3.760E-03 3.760E-03
      1       1        2   5951. 1.027E-02 1.027E-02
      1       1        3   4156. 3.570E-03 3.570E-03
      1       1        4   4949. 8.480E-03 8.480E-03
      1       1        5   5060. 3.680E-03 3.680E-03
```

Exhibit 5-2. Example Portion of an APEX Timestep Output File

Note that the timestep file could be very large if a large number of profiles are simulated or if the APEX timestep is very small. The user may block generation of the *Timestep* file by setting the ***TimestepOut*** parameter to NO in the *Control* file. Also note that if the APEX timestep is equal to the default (1 hour, or **TimestepsPerDay**=24), then the *Timestep* file in general would contain the same information as the *Hourly* file, and thus in this case it is not written.

5.4 Daily File

The *Daily Exposure* file contains a daily time series of a large number of APEX variables for each simulated person or profile. Writing of the file is controlled by the *Control* file variable ***DailyOut.*** The user can control which variables are written to the file via a list of keywords using the *Control* file keyword ***DailyList***. The variables and their corresponding keywords are given in Table 5-4.

Table 5-4. APEX Variables Written to the Daily Output File

Variable	Description	Control File Keyword	Optional
Person	Simulated profile number	-	N
Day	Day number of the simulation	-	N
Diary ID	ID of CHAD diary selected for the current day for the profile	CHADID	Y
Diary Age	Age associated with the selected CHAD diary (may be different from the age of the simulated profile)	CHADAGE	Y
Diary Employment	Employment status associated with the selected CHAD diary	CHADEMP	Y
Diary pool	Index of the APEX diary pool for the current day (as determined by profile functions file)	DIARYPOOL	Y
PAI	Physical activity index, the time-averaged MET over the day for the simulated person	PAI	Y
Key Diary Variable	Daily value of the key diary variable (statistic) used for longitudinal diary assembly for the simulated day for the profile (such as time spent outdoor or in vehicles)	KEYVAR	Y
WindowRes	Conditional variable value indicating whether residence windows are open or closed (as determined by profile functions file)	WINDOWRES	Y
WindowCar	Conditional variable value indicating whether car windows are open or closed (as determined by profile functions file)	WINDOWCAR	Y
SpeedCat	Conditional variable value indicating the speed at which a vehicle is traveling (as determined by profile functions file)	SPEEDCAT	Y
DailyCond1	Value of daily conditional variable 1 (as determined by profile functions file)	DCOND1	Y
DailyCond2	Value of daily conditional variable 2 (as determined by profile functions file)	DCOND2	Y
DailyCond3	Value of daily conditional variable 3 (as determined by profile functions file)	DCOND3	Y
MaxTempCat	Conditional variable giving the category for the maximum temperature for the day (as determined by profile functions file)	MAXTEMPCAT	Y

Variable	Description	Control File Keyword	Optional
AvgTempCat	Conditional variable giving the category for the average temperature for the day (as determined by profile functions file)	AVGTEMPCAT	Y
Maximum Temperature	Maximum hourly temperature for the current day	MAXTEMP	Y
Average Temperature	Average of the hourly temperatures for the current day	AVGTEMP	Y
Average Exposure	Time-averaged pollutant exposure for the day.	AVGEXP	Y
Max 1 Hour Exposure	Maximum 1 hour exposure on the given day; each hourly exposure time-averaged over events.	MAX1EXP	Y
Max 8 Hour Exposure	Maximum 8 hour exposure on the given day; each 8-hour exposure time-averaged over events.	MAX8EXP	Y
Average Dose	Time-averaged pollutant dose for the day. Units of dose depend on pollutant, see *Volume II*.	AVGDOSE	Y
Intake Dose	**PM pollutants only.** Average mass inhaled per minute (includes mass not deposited) during the day (ug/min)	INTAKEDOSE	Y
Deposited Dose	**PM pollutants only**. Total mass deposited in the respiratory system during the day (ug).	DEPDOSE	Y
Max 1 Hour Dose	Maximum 1 hour dose on the given day; each hourly dose time-averaged over events	MAX1DOSE	Y
Max 8 hour Dose	Maximum 8 hour dose on the given day; each 8-hour dose time-averaged over events.	MAX8DOSE	Y
Max End-of-Hour Dose	Maximum dose as calculated at the end of each hour of the day.	MAX1FDOSE	Y

See *Volume II: Technical Support Document* for further information on the diary selection variables, and conditional variables on this list. The exposure and dose keywords will control printing for all pollutants in the simulation; the file headers for these variables will contain the pollutant name.

Note that the *Daily* file could be very large if a large number of profiles or pollutants are simulated. The user may block generation of the daily file by setting the ***DailyOut*** parameter to NO in the *Control* file.

The keywords may be separated by either spaces or commas. An example ***DailyList*** would be:

```
DailyList = CHADID CHADAGE CHADEMP DIARYPOOL PAI KEYVAR WINDOWRES WINDOWCAR
AVGEXP
```

An example portion of a *Daily* file created with the ***DailyList*** example above for an example two-pollutant run (Pol1 and Pol2) is shown in Exhibit 5-3. Note that in the daily file the values may not fall directly under the corresponding label in the file header (in order to minimize file size).

```
 APEX Daily File
 APEX Version 4.0 (dated February 19, 2007)  Run Date = 20070321  Time = 101001
 Location    = Description of Location of the Study Area
 Scenario    = APEX4 Sensitivity Simulation
 Simulation  = ! APEX4 Sensitivity Simulation
 Pollutant   = Pol1 Pol2
 Air Quality = ! Hourly Pol1 air quality data for an example metropolitan area
 Air Quality = ! Hourly Pol2 air quality data for an example metropolitan area

P Day CHADID CHADAge CHADEmp DiaryPool PAI KeyVar WindowRes WindowCar AvgExp-Pol1 AvgExp-Pol2
      1   1 NHW19167A  24 Works  2 2.20  540.00 0 0 7.833E-03 1.436E-02
      1   2 CIN02759A  21 Works  2 2.41   49.00 0 0 7.748E-03 5.456E-02
      1   3 NHW10859A  20 Works  5 2.60  490.00 0 0 9.537E-03 7.764E-02
      1   4 NHA16047A  27 Works  5 1.95    0.00 0 0 8.256E-03 8.379E-02
      1   5 NHW13255A  24 Works  1 2.43  525.00 0 0 4.343E-03 5.747E-02
      1   6 NHW15968A  21 Works  1 1.58  475.00 0 0 6.938E-03 7.345E-02
      1   7 NHW12055A  20 Works  1 1.82  600.00 0 0 6.196E-03 3.253E-02
      1   8 WAS96832A  25 Works  1 2.24   15.00 0 0 4.372E-03 6.744E-02
      1   9 DEN34716B  22 Works  1 3.63   11.00 0 0 6.306E-03 9.222E-02
      1  10 CIN80040B  21 Works  4 2.70  390.00 0 0 5.712E-03 2.543E-02
      1  11 CIN00339B  24 Works  4 2.46  457.00 0 0 6.089E-03 4.334E-02
      1  12 WAS63046A  24 Works  1 2.14    0.00 0 0 6.366E-03 6.435E-02
      1  13 CIN61737C  26 Works  2 2.95   91.00 0 0 4.539E-03 6.765E-02
      1  14 CAA06251A  21 Works  2 2.37  230.00 0 0 2.629E-03 6.279E-02
```

Exhibit 5-3. Example Portion of a Daily Output File

5.5 Profile Summary (Persons) File

This file provides a summary of profile characteristics and exposure/dose for each simulated person. Each record contains values for a number of variables for each simulated individual. A small set of variables are written by default to the file, and additional variables are only written if designated by the user in the *Control* file. The variables are defined using the ***PSumList*** keyword, followed by an equals sign and a list of variable-specific keywords. The available variables and their corresponding keywords are given in Table 5-5.

Table 5-5. APEX Variables Written to the Profile Summary File

Variable	Description	Control File Keyword	Optional
Person	Sequential index number for simulated individual	-	N
Home Sector	Sector in which the person lives (home)	-	N

Variable	Description	Control File Keyword	Optional
Work Sector	Sector in which the person works (=home sector for non-workers)	-	N
Home District	Air district for the home sector	-	N
Work District	Air district for the work sector	-	N
Zone	Meteorology zone for the home sector	-	N
Age	Age of the simulated profile (years)	-	N
Gender	Male or female	-	N
Race	Such as White, Black, Asian, Native American (NatAm), Other (depending on pop. files)	-	N
Employment	Indicates employment outside the home	-	N
Height	Person height (inches)	-	N
Weight	Body mass (pounds)	-	N
Car AC type	Type of air conditioning in the car (depends of *Profile Functions* file)	ACCAR	Y
Home AC type	Type of air conditioning in the residence (depends of *Profile Functions* file)	ACHOM	Y
Disease status	Whether or not a profile is ill (depends on *Prevalence* file)	DISEASE	Y
Gas Pilot	Indicates the presence of a gas pilot light in the home (depends of *Profile Functions* file)	PILOT	Y
Gas Stove	Indicates the presence of a gas stove in the home (depends of *Profile Functions* file)	STOVE	Y
ProfileConditional1	Value of profile conditional variable # 1 for the person	PCOND1	Y
ProfileConditional2	Value of profile conditional variable # 2 for the person	PCOND2	Y
ProfileConditional3	Value of profile conditional variable # 3 for the person	PCOND3	Y
ProfileConditional4	Value of profile conditional variable # 4 for the person	PCOND4	Y
ProfileConditional5	Value of profile conditional variable # 5 for the person	PCOND5	Y
RegionalConditional1	Value of regional conditional variable # 1 for the person	RCOND1	Y
RegionalConditional2	Value of regional conditional variable # 2 for the person	RCOND2	Y

Variable	Description	Control File Keyword	Optional
RegionalConditional3	Value of regional conditional variable # 3 for the person	RCOND3	Y
RegionalConditional4	Value of regional conditional variable # 4 for the person	RCOND4	Y
RegionalConditional5	Value of regional conditional variable # 5 for the person	RCOND5	Y
Number of Events	Number of diary events covering the simulation period for the person	EVENTS	Y
Blood Vol	The volume of blood in the body (ml)	BLOODVOL	Y
BSA	Body surface area (m^2)	BSA	Y
Energy Conversion Factor	Energy conversion factor for person (L-O_2/kcal)	ECF	Y
Lung Diffusivity	A lung diffusivity parameter used in the COHb (CO dose) calculation (ml/min/torr)	DIFFUS	Y
Endogenous CO production 1	Endogenous CO production rate; only used for calculating CO dose (ml/min)	ENDGN1	Y
Endogenous CO production 2	Endogenous CO production rate for women between ages of 12 and 50 for half the menstrual cycle; only used for calculating CO dose (ml/min)	ENDGN2	Y
Hemoglobin	The amount of hemoglobin in the blood (g/ml)	HEMOGLOB	Y
METmax	Maximum obtainable MET level for the person. (MET)	METSMAX	Y
Maximum Oxygen Uptake	Maximum obtainable oxygen uptake rate for person (L-O_2/min)	VO2MAX	Y
Maximum Oxygen Debt	Maximum obtainable oxygen debt for person (ml/kg)	MOXD	Y
Physical Activity Index	Median of the daily PAI values (time-averaged MET on each simulated day)	PAI	Y
Recovery Time	Time required to recover the maximum oxygen debt (hours)	RECTIME	Y
Resting Metabolic Rate	Resting metabolic rate (kcal/min)	RMR	Y
VE Intercept	Regression parameter for the ventilation routine	VEINTER	Y
VE Slope	Regression parameter for the ventilation routine	VERESID	Y

Variable	Description	Control File Keyword	Optional
VE Residual	Regression parameter for the ventilation routine	VESLOPE	Y
Average Exposure	Mean exposure concentration over the simulation (ppm or μg/m^3, as specified in *Control* file)	AVGEXP	Y
Maximum Exposure	Maximum 1-hour exposure concentration over the simulation (ppm or μg/m^3, as specified in *Control* file)	MAXEXP	Y
Average Dose	Mean dose over the simulation. Units of dose depend on pollutant, see *Volume II.*	AVGDOSE	Y
Maximum Dose	Maximum 1-hour average dose over the simulation. Units of dose depend on pollutant, see *Volume II.*	MAXDOSE	Y

The exposure and dose variables listed are written for all pollutants in a multiple-pollutant run. An example portion of a *Profile Summary* file for an example 2-pollutant (Pol1 and Pol2) scenario is given in Exhibit 5-4. This file was created using the *Control* file command:

```
PSumList     =  PAI, AVGEXP
```

Note that each record in the file could be much longer, as many more variables could be printed.

```
APEX Diary Questionnaire File
APEX Version 4.0 (dated February 19, 2007)  Run Date = 20070321  Time = 133813
Location    = Description of Location of the Study Area
Scenario    = APEX4 Sensitivity Simulation
Simulation  = ! APEX4 Sensitivity Simulation
Pollutant   = Pol1 Pol2
Air Quality = ! Hourly Pol1 air quality data for an example metropolitan area
Air Quality = ! Hourly Pol2 air quality data for an example metropolitan area
P HSect WSect HDis WDis Zone Age Gender Race  Empl Height Weight   PAI    AvgExp-Pol1 AvgExp-Pol2
1   513   513  27  27    2   22   Male White Works 71.908 228.339  2.09    9.956E-03    1.005E-02
2    64    64  14  14    2   19   Male Black NoWrk 67.179 138.067  1.74    9.238E-03    9.413E-03
3   359   359  42  42    2   22 Female Other Works 61.018 173.609  1.92    9.749E-03    9.415E-03
4   222   222  39  39    2   15   Male Black NoWrk 68.519 182.139  1.74    9.100E-03    9.131E-03
5   177   177  39  39    2   20 Female Other NoWrk 65.608 160.464  1.65    8.906E-03    9.377E-03
6   287   287  49  49    2   32   Male White Works 65.658 155.154  2.04    9.978E-03    1.059E-02
7   688   688  28  28    2   48 Female Black Works 66.264 183.261  1.97    8.873E-03    9.257E-03
8   661   661  23  23    2   50 Female White Works 60.355 106.818  1.93    8.765E-03    8.625E-03
9   280   280  55  55    2   39   Male Black NoWrk 69.081 209.165  1.76    9.120E-03    9.331E-03
10  793   793  17  17    2   32 Female White NoWrk 65.700 172.692  1.87    1.020E-02    1.041E-02
```

Exhibit 5-4. Portion of a Profile Summary File

5.6 Microenvironmental Results File

The *Microenvironmental Results* file contains hourly values for a number of microenvironment parameters and variables for all microenvironments, for all persons in a simulation. The file is pollutant-specific, so one file will be created for each pollutant in the simulation. The variable values are written for the "home," "work," and "other" locations; there is a set of microenvironment concentrations associated with each location for each profile. This file may be useful in examining/testing the effects of conditional values on microenvironment concentrations.

The creation of the file for all pollutants is controlled by the *Control* file variable ***MResOut*.** The files are written if ***MResOut*** =YES**.** The default is NO**,** as **these files are very large, and writing them greatly affects the speed of the simulation.** The printing of the optional variables is dictated by the Control file keyword ***MResList*** via a comma- or space-separated list of variable keywords. The ***MResList*** will control the writing of the Microenvironment Results file for all of the simulation pollutants. The variables that may be written to the file and their corresponding keywords are given in Table 5-6.

Table 5-6. APEX Variables Written to the Microenvironmental Results File

Variable	Description	Control File Keyword	Optional
Person	The number of the simulated profile	-	N
Hour #	Hour of the simulation. Hour ranges from -23 to 24 times the number of days in the simulation. The hours -23 to 0 are included because APEX extends the calculation of the microenvironment concentrations to include the 24 hours prior to the beginning of the simulation	-	N
Micro #	Microenvironment number (See Section 4.16).	-	N
Location	Apex calculates concentrations for each microenvironment for home (1), work (2), and other (3) locations (see *Volume II*). All are listed in the file.	-	N
Proximity	Proximity factor: microenvironment parameter, greater than 0.	PRX	Y
Penetration	Penetration factor: microenvironment parameter, ranging from 0 to 1.	PEN	Y
CSum	Sum of concentration sources (CSource) terms	CSUM	Y
Ambient Concentration	Pollutant concentration associated with the location sector and hour (as determined from the *Air Quality Data* file).	AMB	Y

Variable	Description	Control File Keyword	Optional
Micro Concentration	Pollutant concentration in the microenvironment	CONC	Y
ESum	Sum of Emission Sources (ESource) terms (µg/hr).	ESUM	Y
Source Strength	Combined source strength for emission and concentration sources in $\mu g/m^3/hr$.	SOURCE	Y
Micro Volume	Volume of the microenvironment in m^3.	VOL	Y
Air Exchange Rate (AER)	Rate of air exchange in microenvironment (1/hr).	AER	Y
Removal (Decay) Rate	Total removal rate of pollutant from microenvironment (1/hr).	RR	Y
WindowRes	Conditional variable value indicating whether residence windows are open or closed (as determined by profile functions file)	WINDOWRES	Y
WindowCar	Conditional variable value indicating whether car windows are open or closed (as determined by profile functions file)	WINDOWCAR	Y
MaxTempCat	Daily maximum temperature category conditional variable - will be same for all hours in a day. (as determined by profile functions file)	MAXTEMPCAT	Y
AvgTempCat	Daily average temperature category conditional variable - will be same for all hours in a day. (as determined by profile functions file)	AVGTEMPCAT	Y
SpeedCat	Conditional variable value indicating the speed at which a vehicle is traveling (as determined by profile functions file)	SPEEDCAT	Y
DailyConditional1	Value of daily conditional variable 1 for the hour	DCOND1	Y
DailyConditional2	Value of daily conditional variable 2 for the hour	DCOND2	Y
DailyConditional3	Value of daily conditional variable 3 for the hour	DCOND3	Y
TempCat	Hourly temperature category conditional variable	TEMPCAT	Y
HumidCat	Hourly humidity category conditional variable	HUMIDCAT	Y
PrecipCat	Hourly precipitation category conditional variable	PRECIPCAT	Y

Variable	Description	Control File Keyword	Optional
WindCat	Hourly wind speed category conditional variable	WINDCAT	Y
DirCat	Hourly wind direction category conditional variable	DIRCAT	Y
Day	Day of the simulation	DAY	Y
Month	Month of the year	MONTH	Y
Air District	Air district person is in (i.e., the district corresponding to the home/work/other location)	DISTRICT	Y
DayWeek	Day of the week	DAYWEEK	Y

See *Volume III: Programmer's Guide* for details on the microenvironment parameters, microenvironment concentration equations, and conditional variables.

A number of the parameters in the file are undefined for a FACTORS microenvironment (See Section 4.20.1). These parameters will be padded with 0 in that case.

An example use of **MResList** in the Control file is:

```
MResList   =   AER, PRX, PEN, AMB, CONC, MAXTEMPCAT, AVGTEMPCAT, WINDOWRES
```

The resulting example *Microenvironmental Results* file for an example pollutant (Pol1) is given in Exhibit 5-5. Note that in the file the variable values may not fall directly under the corresponding label in the file header (in order to minimize file size).

```
APEX Microenvironmental Results File
APEX Version 4.0 (dated February 19, 2007)  Run Date = 20070321  Time = 152320
Location    = Description of Location of the Study Area
Scenario    = APEX4 Sensitivity Simulation
Simulation  = ! APEX4 Sensitivity Simulation
Pollutant   = Pol1
Air Quality = ! Hourly Pol1 air quality data for an example metropolitan area
Simulation Start Date = 20040101

Person Micro Loc Hour Prx Pen Amb Conc AER WindowRes MaxTempCat AvgTempCat TempCat
      1  1 1 -23 1.0000 1.0000 8.000E-03 4.227E-04  0.4104 0 1 1 1
      1  1 1 -22 1.0000 1.0000 9.000E-03 6.518E-04  0.5042 0 1 1 1
      1  1 1 -21 1.0000 1.0000 7.000E-03 7.044E-04  0.6962 0 1 1 1
      1  1 1 -20 1.0000 1.0000 2.000E-03 2.335E-04  0.5010 0 1 1 1
      1  1 1 -19 1.0000 1.0000 7.000E-03 1.645E-04  0.1511 0 1 1 1
      1  1 1 -18 1.0000 1.0000 2.300E-02 1.712E-03  0.5822 0 1 1 1
      1  1 1 -17 1.0000 1.0000 2.100E-02 1.922E-03  0.6193 0 1 1 1
      1  1 1 -16 1.0000 1.0000 1.800E-02 1.398E-03  0.4841 0 1 1 1
      1  1 1 -15 1.0000 1.0000 1.800E-02 1.207E-03  0.4370 0 1 1 1
      1  1 1 -14 1.0000 1.0000 1.900E-02 1.192E-03  0.4138 0 1 1 1
      1  1 1 -13 1.0000 1.0000 2.100E-02 1.496E-03  0.4923 0 1 1 1
      1  1 1 -12 1.0000 1.0000 2.400E-02 3.147E-03  1.0217 0 1 1 1
      1  1 1 -11 1.0000 1.0000 2.800E-02 3.395E-03  0.8523 0 1 1 1
      1  1 1 -10 1.0000 1.0000 3.000E-02 3.091E-03  0.6968 0 1 1 1
      1  1 1  -9 1.0000 1.0000 3.200E-02 2.390E-03  0.4730 0 1 1 1
      1  1 1  -8 1.0000 1.0000 3.000E-02 1.132E-03  0.1955 0 1 1 1
      1  1 1  -7 1.0000 1.0000 2.800E-02 1.395E-03  0.3449 0 1 1 1
      1  1 1  -6 1.0000 1.0000 2.600E-02 1.487E-03  0.3753 0 1 1 1
      1  1 1  -5 1.0000 1.0000 2.200E-02 1.440E-03  0.4299 0 1 1 1
      1  1 1  -4 1.0000 1.0000 2.300E-02 1.960E-03  0.6052 0 1 1 1
      1  1 1  -3 1.0000 1.0000 2.600E-02 2.610E-03  0.7176 0 1 1 1
      1  1 1  -2 1.0000 1.0000 2.300E-02 1.683E-03  0.4316 0 1 1 1
      1  1 1  -1 1.0000 1.0000 2.300E-02 1.279E-03  0.3517 0 1 1 1
      1  1 1   0 1.0000 1.0000 2.200E-02 1.226E-03  0.3640 0 1 1 1
      1  1 1   1 1.0000 1.0000 8.000E-03 6.081E-04  0.4104 0 1 1 1
```

Exhibit 5-5. Portion of an Environmental Results File

5.7 Microenvironmental Summary File

This file provides the amount of time spent, mean exposure concentration, and maximum exposure concentration in each microenvironment during the period of simulation, for each simulated person. The *Microenvironmental Summary* file is pollutant-specific, and thus one is created for each pollutant in the simulation. After the six header records and one blank record, there is one record labeling the columns of the subsequent records in the file. These labels and descriptions of the values in the corresponding columns are given in Table 5-7. The first part of an example Microenvironmental Summary File is shown in Exhibit 5-6.

Table 5-7. Format of the APEX Microenvironmental Summary File

Column	Label	Type	Description
1	Person	Num	Profile number - Sequential index number for the simulated individual
2	Micro	Num	Microenvironment number - Sequential index number for each microenvironment (as designated in the Microenvironment Mapping file)

3	Name	Char	Microenvironment name (as designated in the Microenvironment Mapping file) (maximum of 40 characters)
4	Minutes	Num	Total time spent in the microenvironment by this individual (minutes)
5	MeanConc	Num	Average concentration during the time spent in the microenvironment by this individual (ppm or µg/m3, as specified in the Control file)
6	MaxConc	Num	Maximum concentration during the time spent in the microenvironment by this individual (ppm or µg/m3, as specified in the Control file)

```
APEX Microenvironmental Summary File
 APEX Version 3.4 August 30, 2005 Run Date = 20051104 Time = 180331.421
 Location    = Location of the Study Area
 Pollutant   = Ozone
 Scenario    = Example APEX4 Simulation
 Parameters  = APEX version 4 Simulation Control File
  Person Micro   Name                                        Minutes      MeanConc       MaxConc
        1     0   ZeroExposure                                     0        0.0000        0.0000
        1     1   Indoors-residence                             1338        0.0028        0.0070
        1     2   Indoors-bars_and_restaurants                    60        0.0076        0.0080
        1     3   Indoors-schools                                  0        0.0000        0.0000
        1     4   Indoors-day_care_centers                         0        0.0000        0.0000
        1     5   Indoors-other                                    2        0.0004        0.0004
        1     6   Outdoors-near_road                               0        0.0000        0.0000
        1     7   Outdoors-other                                  10        0.0089        0.0089
        1     8   In                                              30        0.0043        0.0056
        1     9   In                                               0        0.0000        0.0000
        2     0   ZeroExposure                                     0        0.0000        0.0000
```

Exhibit 5-6. Portion of a Microenvironmental Summary File

5.8 Output Tables File

This file provides up to 242 summary tables, depending on the table specifications in the *Simulation Control* file. The first 130 are exposure summary tables, while the last 112 are dose summary tables. The *Tables* file is pollutant-specific, and thus one is created for each pollutant in the simulation.

5.8.1 Exposure Summary Tables

APEX writes out up to 130 different exposure summary tables. There are eleven different types of exposure tables:

1. Minutes in each exposure interval by microenvironment
2. Minutes at or above each exposure level by microenvironment
3. Person-days at or above each daily maximum 1-hour exposure level

4. Person-days at or above each daily maximum 8-hour exposure level
5. Person-days at or above each daily maximum timestep exposure level
6. Number of simulated persons with multiple exposures at or above each daily maximum 1-hour exposure level
7. Number of simulated persons with multiple exposures at or above each daily maximum 8-hour exposure level
8. Number of simulated persons with multiple exposures at or above each daily maximum timestep exposure level.
9. Number of simulated persons with multiple exceedances (in the simulation) of the threshold timestep exposure levels.
10. Person-days at or above each daily average exposure level
11. Number of persons at or above each overall average exposure level

Table types 1, 2, 10, and 11 are generated only once, for the entire population. Table types 3 to 9 are generated for six population subgroups, under three exertion levels. The six population subgroups are as follows:

1. All Persons. The table statistics are based on the entire population.

2. Children. The table statistics are based on the population of children, as defined by the age range given by the *Control* file settings ***ChildMin*** and ***ChildMax***.

3. Active Persons. The table statistics are based on the population of people having a median Physical Activity Index (PAI, mean MET) over the whole simulation period that exceeds the value designated by the *Control* file setting ***ActivePAI***.

4. Active Children. The table statistics are based on the population of active children, as determined by the *Control* file settings ***ChildMin***, ***ChildMax***, and ***ActivePAI***.

5. Ill Persons. The table statistics are based on the population of ill people. The population is determined by the probabilities given in the *Prevalence* file. This population is only considered if the input variable ***Disease*** is set in the *Control* file.

6. Ill Children. The table statistics are based on the population of ill people. The population is determined by the probabilities given in the *Prevalence* file and the *Control* file settings ***ChildMin* and *ChildMax***. This population is only considered if the input setting ***Disease*** is set in the *Control* file.

The three exertion levels are:

1. All Exertion Conditions. The table statistics are based on exposures experienced by the population subgroup under any ventilatory conditions.

2. Moderate Exertion. The table statistics are based on exposures experienced by the population subgroup only during periods in which their average equivalent ventilation rate (EVR) is in the "moderate" range. The period of time during which EVR is averaged is either 1 hour or 8 hours, based on the table being generated. The "moderate" EVR ranges are defined by the *Control* file settings ***ModEVR1*** and ***HeavyEVR1*** (for 1-hour exposures) and ***ModEVR8*** and ***HeavyEVR8*** (for 8-hour exposures). An individual's EVR is in the moderate range if it is greater than or equal to the ***ModEVR#*** setting and less than the ***HeavyEVR#*** setting for the exposure period.

3. Heavy Exertion. The table statistics are based on exposures experienced by the population subgroup only during periods in which their average equivalent ventilation rate (EVR) is in the "heavy" range. The period of time during which EVR is averaged is either 1 hour or 8 hours, based on the table being generated. The "heavy" EVR ranges are defined by the *Control* file settings ***HeavyEVR1*** (for 1-hour exposures) and ***HeavyEVR8*** (for 8-hour exposures). An individual's EVR is in the heavy range if it is greater than or equal to the ***HeavyEVR#*** setting for the exposure period.

For each table that is generated, APEX prints out a label that identifies the table uniquely. For example, a table of type #1, for all people under all exertion conditions, has the identifier **TIME, WITHIN, ALL, ALL**. Users can reference these identifier labels in custom programs that read in and process the APEX *Tables* file.

Exposure Table Type #1: Minutes in each Exposure Interval by Microenvironment
This table lists the total minutes spent by all simulated persons in each microenvironment when exposure concentration is within various ranges. The bounds of a range are specified at the top of each column and the top of the next column to the right (Exhibit 5-7). For each microenvironment, the table provides three rows of data for the following three variables:

- Minutes—The number of person-minutes summed over all the simulated persons that are spent in the specified microenvironment and that fall within the exposure concentration range bounded by the values indicated at the top of the column and the top of the next column to the right;
- Row_%—The percent of the minutes spent in the specified microenvironment that fall within the exposure concentration range; and
- Tot_%—the percent of the total minutes that are spent in the microenvironment and that fall within the exposure concentration range.

```
TIME,WITHIN,ALL,ALL
Exposure: Minutes in each Exposure interval ( ppm ), by microenvironment, for N =    1000 Profiles

       Level:          0.0000        2.0000        4.0000       10.0000     20.0000     30.0000     40.0000     50.0000
Micro  ------------------------------------------------------------------------------------------------------------------
   0   Minutes        315200.            0.            0.            0.          0.          0.          0.          0.
   0     Row_%       100.0000        0.0000        0.0000        0.0000      0.0000      0.0000      0.0000      0.0000
   0     Tot_%         0.0600        0.0000        0.0000        0.0000      0.0000      0.0000      0.0000      0.0000
   1   Minutes     319260868.     38420255.      5720925.       80294.          0.          0.          0.          0.
   1     Row_%        87.8339       10.5700        1.5739        0.0221      0.0000      0.0000      0.0000      0.0000
   1     Tot_%        60.7422        7.3098        1.0885        0.0153      0.0000      0.0000      0.0000      0.0000
   2   Minutes             0.     10634094.            0.     28189514.          0.          0.          0.          0.
   2     Row_%         0.0000       27.3908        0.0000       72.6092      0.0000      0.0000      0.0000      0.0000
   2     Tot_%         0.0000        2.0232        0.0000        5.3633      0.0000      0.0000      0.0000      0.0000
   3   Minutes      87632542.      4338531.       868903.        29823.       1229.        150.          0.          0.
   3     Row_%        94.3592        4.6716        0.9356        0.0321      0.0013      0.0002      0.0000      0.0000
   3     Tot_%        16.6729        0.8254        0.1653        0.0057      0.0002      0.0000      0.0000      0.0000
   4   Minutes      26980476.      2603103.       511191.        12511.        391.          0.          0.          0.
   4     Row_%        89.6133        8.6460        1.6979        0.0416      0.0013      0.0000      0.0000      0.0000
   4     Tot_%         5.1333        0.4953        0.0973        0.0024      0.0001      0.0000      0.0000      0.0000
-------------------------------------------------------------------------------------------------------------------------
```

Exhibit 5-7. Example of Exposure Table Type #1 in the Output Tables File

Exposure Table Type #2: Minutes in each Exposure Interval by Microenvironment

This table is similar to Table #1, except that it reports the cumulative person-minutes that are spent in a microenvironment with an exposure concentration that equals or exceeds the value indicated at the top of the column.

Exposure Table Type #3: Person-Days at or above each Daily Maximum 1-Hour Exposure Level

This table provides a statistical summary of the cumulative person-days, for both simulated persons and the population in the study area, with a daily maximum 1-hour (hourly) average exposure concentration that equals or exceeds the value indicated at the top of the column (Exhibit 5-8). The interpretations of the variables in Table Type #3 (and other "person-days" tables) are provided in Table 5-8.

```
PERSONDAYS,DM1H,ALL,ALL
Exposure: Person-Days at or above each Daily Maximum 1-Hour Exposure Level ( ppm ), for N = 1000 Profiles. Area Population =3976069
Group: All People

  Level:             0.000         5.000      10.000      20.000    30.000    40.000    50.000    75.000
---------------------------------------------------------------------------------------------------------
 Counts(Pop):     0.145E+10     0.951E+09   0.386E+09   0.755E+05 0.795E+04 0.000E+00 0.000E+00 0.000E+00
 #Meet (Pop):       3976069       3976069     3976069       63617      7952         0         0         0
 %Meet (Pop):       100.000       100.000     100.000       1.600     0.200     0.000     0.000     0.000
 Mean       :       365.000       239.258      97.140       0.019     0.002     0.000     0.000     0.000
 Std.Dev.   :         0.000        34.182      22.835       0.157     0.045     0.000     0.000     0.000
 CV         :         0.000         0.143       0.235       8.266    22.349     0.000     0.000     0.000
 Minimum    :       365.000       137.000      42.000       0.000     0.000     0.000     0.000     0.000
 10.0 %ile  :       365.000       188.000      66.000       0.000     0.000     0.000     0.000     0.000
 25.0 %ile  :       365.000       214.000      82.000       0.000     0.000     0.000     0.000     0.000
 50.0 %ile  :       365.000       246.000      96.000       0.000     0.000     0.000     0.000     0.000
 75.0 %ile  :       365.000       268.000     116.000       0.000     0.000     0.000     0.000     0.000
 90.0 %ile  :       365.000       278.000     128.000       0.000     0.000     0.000     0.000     0.000
 95.0 %ile  :       365.000       283.000     133.000       0.000     0.000     0.000     0.000     0.000
 99.0 %ile  :       365.000       292.000     143.990       1.000     0.000     0.000     0.000     0.000
 Maximum    :       365.000       306.000     164.000       2.000     1.000     0.000     0.000     0.000
 Mean  (%)  :       100.000        65.550      26.614       0.005     0.001     0.000     0.000     0.000
 Min   (%)  :       100.000        37.534      11.507       0.000     0.000     0.000     0.000     0.000
 Max   (%)  :       100.000        83.836      44.932       0.548     0.274     0.000     0.000     0.000
 Counts(Sim):     0.365E+06     0.239E+06   0.971E+05   0.190E+02 0.200E+01 0.000E+00 0.000E+00 0.000E+00
 #Meet (Sim):          1000          1000        1000          16         2         0         0         0
```

Exhibit 5-8. Example of Exposure Table Type #3 in the Output Tables File

Table 5-8. Interpretation of the Variables in Exposure Table Type #3 and Other "Person-Days" Based Tables.

Table entry	Interpretation
Counts (Pop)	Total number of person-days at or above the level specified at the top of each column for the population [of the subgroup] in the study area [while at this exertion].
#Meet (Pop)	Number of persons [in the subgroup] in the study area population who have at least one exposure at or above the level specified at the top of each column [while at this exertion]. **NOTE**: For exertion level tables, the 0.0 level count will not necessarily be equal to the population of the subgroup, since some persons may have no events at the exertion level.
%Meet (Pop)	Percentage of people [in the subgroup] in the population who have at least one exposure at or above the level specified at the top of each column [while at this exertion]. **NOTE:** For exertion level tables this may not be 100% at the 0.0 level, since some persons may have no events at the exertion level.
Mean	Mean number of days per person [in the subgroup] during which an exposure at or above the level specified at the top of each column is experienced [while at this exertion].

Std. Dev.	Standard deviation across persons [in the subgroup] in the number of days during which an exposure at or above the level specified at the top of each column is experienced [while at this exertion].
CV	Coefficient of variation across persons [in the subgroup] in the number of days during which an exposure at or above the level specified at the top of each column is experienced [while at this exertion].
Minimum	The lowest total number of days across persons [in the subgroup] during which an exposure at or above the level specified at the top of each column is experienced [while at this exertion].
Percentiles	The Nth percentile of number of days across persons [in the subgroup] during which an exposure at or above the level specified at the top of each column is experienced [while at this exertion].
Maximum	The highest total number of days across persons [in the subgroup] during which an exposure at or above the level specified at the top of each column is experienced [while at this exertion].
Mean (%)	Mean number of days per person [in the subgroup] during which an exposure at or above the level specified at the top of each column [while at this exertion] is experienced, as percentage of possible days.
Min (%)	The lowest total number of days across persons [in the subgroup] during which an exposure at or above the level specified at the top of each column is experienced [while at this exertion], as percentage of possible days.
Max (%)	The highest total number of days across persons [in the subgroup] during which an exposure at or above the level specified at the top of each column is experienced [while at this exertion], as percentage of possible days.
Counts (Sim)	Total number of simulated person-days [in the subgroup] during which an exposure at or above the level specified at the top of each column is experienced [while at this exertion]. **NOTE:** At the 0.0 level in the exertion-dependent tables, Counts(Sim) might not necessarily be equal to #Meet(Sim)*NumDays, since some persons may have no events at the exertion level.
#Meet (Sim)	The total number of simulated persons [in the subgroup] who experience at least one exposure at or above the level specified at the top of each column [while at this exertion].

Exposure Table Type #4: Person-Days at or above each Daily Maximum 8-Hour Exposure Level

This table provides a statistical summary of the cumulative person-days, for both simulated persons and the population in the study area, with a daily maximum 8-hour average exposure concentration that equals or exceeds specified levels. The table and its interpretation are the same as Table #3 (Exhibit 5-8) except that the exposure metric is the daily max 8-hour average exposure concentration.

Exposure Table Type #5: Person-Days at or above each Daily Maximum Timestep Exposure Level

This table provides a statistical summary of the cumulative person-days, for both simulated persons and the population in the study area, with a daily maximum timestep average exposure concentration that equals or exceeds specified levels. The table and its interpretation are the same as Table #3 (Exhibit 5-8) except that the exposure metric is the daily max timestep average exposure concentration. This table is not written if the timestep is equal to one hour.

Exposure Table Type #6: Number of Simulated Persons with Multiple Exposures at or above each Daily Maximum 1-Hour Exposure Level

This table simply provides a count of the number of simulated persons who have at least 1 (2, 3, 4, 5, 6) days in the simulation during which they have experienced an exposure above each of the daily maximum 1-hour exposure levels. An example is shown in Exhibit 5-9.

```
MULTIPLE,DM1H,ALL,ALL
Exposure: Number of Simulated Persons with Multiple Exposures at or above each Daily
Maximum 1-Hour Exposure Level (ppm),for N =    1000 Profiles.
Group: All People

      At least 1   At least 2   At least 3   At least 4   At least 5   At least 6
        Exposure    Exposures    Exposures    Exposures    Exposures    Exposures
  Level-------------------------------------------------------------------------
   0.000      1000         1000         1000         1000         1000         1000
   5.000      1000         1000         1000         1000         1000         1000
  10.000      1000         1000         1000         1000         1000         1000
  20.000        16            3            0            0            0            0
  30.000         2            0            0            0            0            0
  40.000         0            0            0            0            0            0
  50.000         0            0            0            0            0            0
  75.000         0            0            0            0            0            0
---------------------------------------------------------------------------------
```

Exhibit 5-9. Example of Exposure Table Type #6 in the Output Tables File.

Exposure Table Type #7: Number of Simulated Persons with Multiple Exposures at or above each Daily Maximum 8-Hour Exposure Level

This table simply provides a count of the number of simulated persons who have at least 1 (2, 3, 4, 5, 6) days in the simulation during which they have experienced an exposure above each of the daily maximum 8-hour exposure levels. The table is the same as Table #6 (Exhibit 5-9) except that the exposure metric is the daily max 8-hour average exposure concentration.

Exposure Table Type #8:Number of simulated persons with multiple exposures at or above each daily maximum timestep exposure level.
This table provides a count of the number of simulated persons who have at least 1 (or 2, 3, 6, etc) days in the simulation during which they have experienced an exposure above each of the daily maximum timestep exposure levels. The table is the same as Table #6 (Exhibit 5-9) except that the exposure metric is the daily max timestep average exposure concentration. This table is not written if the timestep is equal to one hour.

Exposure Table Type #9: Number of simulated persons with multiple exposures at or above some threshold timestep exposure level.
This table provides a count of the number of simulated persons who have at least 1 (or 2, 30, or 300, for example) timesteps in the entire simulation during which they have experienced an exceedance of each timestep threshold exposure level. The different number of exceedances to include in the table are listed in the *Control* file using the keyword **TSMultiLevels**. The threshold exposures are listed using the keyword **TSExp**. This table is not written if the timestep is equal to one hour.

Exposure Table Type #10: Person-Days at or above each Daily Average Exposure Level
This table provides a statistical summary of the cumulative person-days, for both simulated persons and the population in the study area, with a daily average exposure concentration that equals or exceeds specified levels. The table and its interpretation are the same as Table Type #3 (Exhibit 5-8) except that the exposure metric is the daily average exposure concentration.

Exposure Table Type #11: Persons at or above each Overall Average Exposure Level
This table provides a statistical summary of cumulative numbers of both simulated persons and people in the study area whose overall average exposure concentrations equal or exceed specified levels. The overall average exposure concentration is the average of hourly exposure concentrations over the whole period of simulation. An example of this table is provided in Exhibit 5-10.

```
PERSONDAYS,SAVG,ALL,ALL
Exposure: Persons at or above each Overall Average Exposure Level ( ppm ), for N =    1000 Profiles.
Area Population =   3976069

   Level:            0.000         0.500       1.000       2.000     3.000     4.000     5.000
-----------------------------------------------------------------------------------------------
 Counts(Pop):     0.398E+07     0.398E+07   0.392E+07   0.386E+06 0.000E+00 0.000E+00 0.000E+00
 #Meet (Pop):       3976069       3976069     3916428      385679         0         0         0
 %Meet (Pop):       100.000       100.000      98.500       9.700     0.000     0.000     0.000
 Counts(Sim):     0.100E+04     0.100E+04   0.985E+03   0.970E+02 0.000E+00 0.000E+00 0.000E+00
 #Meet (Sim):          1000          1000         985          97         0         0         0
-----------------------------------------------------------------------------------------------
```

Exhibit 5-10. Example of Exposure Table Type #11 in the Output Tables File.

5.8.2 Dose Summary Tables

APEX writes out up to 112 different exposure summary tables. There are 10 different types of dose summary tables. The contents of each table type are described in detail below. Table types 7-10 are generated only once, for the entire population. Table types 1-6 are each generated for six population subgroups, under three exertion levels. See the previous section on Exposure tables for the definition of population subgroups and exertion levels. For the pollutant CO, dose is blood dose (%COHb), and for any PM pollutant the dose is the rate of mass deposited in the respiratory system in ug/min (See *Volume II*). For all other pollutants dose is simply exposure*ventilation.

Dose Table Type #1— Person-Days at or above each Daily Max End-of-Hour Dose Level
This table provides a statistical summary of the cumulative person-days for both simulated persons and the population in the study area, for which the daily maximum end-of-hour dose is equal to or exceeds specified levels. The format of the table is the same as Exposure Table #3 (Exhibit 5-8).

Dose Table Type #2— Person-Days at or above each Daily Max 1-Hour Dose Level
This table provides a statistical summary of the cumulative person-days, for both simulated persons and the population in the study area, for which the daily maximum 1-hour average dose is equal to or exceeds specified levels. The format of the table is the same as Exposure Table #3 (Exhibit 5-8). The definitions of the variables in this table can be found in Table 5-8.

Dose Table Type #3—Person-Days at or above each Daily Max 8-Hour Dose Level
This table provides a statistical summary of the cumulative person-days, for both simulated persons and the population in the study area, for which the daily maximum 8-hour average dose is equal to or exceeds specified levels. The format of the table is the same as Exposure Table #3 (Exhibit 5-8). The definitions of the variables in this table can be found in Table 5-8.

Dose Table Type #4: Person-Days at or above each Daily Maximum Timestep Dose Level
This table provides a statistical summary of the cumulative person-days, for both simulated persons and the population in the study area, with a daily maximum timestep average dose that equals or exceeds specified levels. The table and its interpretation are the same as Exposure Table #3 (Exhibit 5-8) except that the exposure metric is the daily max timestep average exposure concentration. This table is not written if the timestep is equal to one hour. The definitions of the variables in this table can be found in Table 5-8.

Dose Table Type #5: Number of Simulated Persons with Multiple Timestep Doses at or above some Threshold Timestep Dose Level.
This table provides a count of the number of simulated persons who have at least 1 (or 2, 30, or 300, for example) timesteps in the entire simulation during which they have experienced an exceedance of each timestep threshold dose level. The different number of exceedances to include in the table are listed in the *Control* file using the keyword **TSMultiLevels**. The threshold exposures are listed using the keyword **TSDose**. This table is not written if the timestep is equal to one hour.

Dose Table #6— Person-Days at or above each Daily Average Dose Level
This table provides a statistical summary of the cumulative person-days, for both simulated persons and the population in the study area, for which the daily average dose is equal to or exceeds specified levels. The format of the table is the same as Exposure Table #3 (Exhibit 5-8). The definitions of the variables in this table can be found in Table 5-8.

Dose Table #7— Persons at or above each Overall Average Dose Level

This table provides a statistical summary of cumulative numbers of both simulated persons and the people in the study area whose overall average doses are equal to or exceed a specified level. The overall average dose is the average of hourly dose levels over the whole period of simulation.

Dose Table #8—Person-hours at or above each End-of-Hour Dose Level
This table provides a statistical summary of the number of person-hours, for both simulated persons and the population in the study area, for which each end-of-hour dose level is equal to or exceeds specified levels. The format of the table is the same as Exposure Table #3 (Exhibit 5-8), except that the time units are hours rather than days. The definitions of the variables in this table can be found in Table 5-8.

Dose Table #9— Minutes in each Dose Interval
This table provides a statistical summary of cumulative person-minutes, for both simulated persons and the population in the study area, for which the dose (for example, blood %COHb level) is within a specified range. The bounds of the dose range are specified by the levels at the top of each column and the top of the next column to the right. The definitions of the variables in this table are similar to those found in Table 5-8, except that the time units are in minutes rather than days.

Dose Table #10— Minutes at or above each Dose Level
This table provides a statistical summary of cumulative person-minutes spent by both simulated persons and the population in the study area, for which the dose (for example, blood %COHb level) is equal to or exceeds specified levels. The definitions of the variables in this table are similar to those found in Table 5-8, except that the time units are in minutes rather than days.

5.9 Sites File

The *Sites* output file lists the sectors, air districts, and zones in the study area, and identifies the mapping between them. Thus, each record contains the following:

- **Sector#**—Sector ID
- **Latitude**—Sector latitude (decimal degrees)
- **Longitude**—Sector longitude (decimal degrees)
- **Sectorname**—Sector name
- **Air#**—Air district ID
- **Airdistance**—Distance from air district to sector (km)
- **Airlatitude**—Air district latitude (decimal degrees)
- **Airlongitude**—Air district longitude (decimal degrees)
- **Airname**—Air district name
- **Tem#**—Meteorology zone ID
- **Temdistance**—Distance from zone to sector (km)
- **Temlatitude**—Zone latitude (decimal degrees)
- **Temlongitude**—Zone longitude (decimal degrees)
- **Temname**—Zone name

5.10 Events File

The *Events* file contains a summary of the activity diary with accompanying exposure and dose, at the diary event level. The variables printed in this file include:

- **Person** – the profile number of the simulated individual
- **Seq** – the event number for the profile
- **Day** – the day number of the simulation, incremented from Day 1 of simulation
- **Year** – the year of the event (4-digit)
- **Mn** – the month of the event (1 to 12)
- **Dy** – the day of the week the event (1 to 7)
- **Hr** – the hour of the event (1 to 24)
- **Dur** – the duration of the event (integer minutes)
- **Act** – the MET distribution code for the event activity
- **Mic** – the microenvironment code for the event
- **HW** – 1=event in home sector, 2=event in work sector, 3=elsewhere
- **Exposure** – Exposure level during the event (ppm or $\mu g/m^3$)

Optionally, the user can ask APEX to include the variables:

- **METS** – MET level for the event (units)
- **UMET** – Unmodified MET level for the event (units)
- **VA** – Alveolar ventilation during the event (ml/min)
- **VE** – Ventilation during the event (ml/min)
- **EVR** – Equivalent Ventilation rate
- **DEFICIT –** Oxygen debt, percent of nominal

by including the keyword EVENTSLIST, and listing the variable names to be included. If ***DoDose*** = Yes in the *Control* file, then two variables related to dose will be printed for all cases, and an additional two will be printed for PM exposure:

- **Dose** – Dose over the event
- **FDose** – Final dose for the event
- **DepDose** – Deposited mass dose for PM events
- **IntakeDose** – Intake dose rate for the PM event

An example of the EVENTSLIST keyword would be:

```
EventsList   =   UMET VA VE EVR METS DEFICIT
```

```
 APEX Events File
 APEX Version 4.3 (dated June 13, 2008)  Run Date = 20081014  Time = 161345
 Location    = NYC
 Scenario    = NYCPM, RandomSeed = 0, N = 50
 Simulation  = APEX NYC simulation - Benchmark Test #1
 Pollutant   = pm1 pm2 pm3 pm4
 Air Quality = ! PM25 Air Quality Data for the 2003 AMI NYC Exposure Study Area (ug/m3)
 Air Quality = ! PM25 Air Quality Data for the 2003 AMI NYC Exposure Study Area (ug/m3)
 Air Quality = ! PM25 Air Quality Data for the 2003 AMI NYC Exposure Study Area (ug/m3)
 Air Quality = ! PM25 Air Quality Data for the 2003 AMI NYC Exposure Study Area (ug/m3)

  Person   Seq  Day Year Mn Dy Hr Dur Act Mic HW   UMET   METS       VA       VE     EVR      E>
DepDose-pm1      Exp-pm2      Dose-pm2  IntakeDose-pm2  DepDose-pm2      Exp-pm3     Dose-pm3  Ir
Dose-pm4  IntakeDose-pm4  DepDose-pm4
       1     1    1 2003  2  1  1  60  50   1  1  3.521  3.529   21405.   33406.  15.154 4.522E-
2.604E-03 1.510E-02 1.562E-01 2.006E-01 2.075E-03 6.700E-03 1.245E-01 2.006E-01 6.577E-03 6.689E
       1     2    1 2003  2  1  2  60  50   1  1  2.767  2.777   16847.   26039.  11.812 4.591E-
2.344E-03 1.195E-02 1.406E-01 2.050E-01 1.388E-03 5.337E-03 8.327E-02 2.050E-01 5.112E-03 5.328E
       1     3    1 2003  2  1  3  60  50   1  1  2.861  2.862   17358.   21035.   9.542 4.570E-
2.064E-03 9.613E-03 1.239E-01 2.033E-01 9.688E-04 4.275E-03 5.813E-02 2.033E-01 3.958E-03 4.268E
       1     4    1 2003  2  1  4  60  50   1  1  3.398  3.398   20614.   31667.  14.365 4.494E-
2.569E-03 1.423E-02 1.541E-01 1.984E-01 1.873E-03 6.284E-03 1.124E-01 1.984E-01 6.143E-03 6.273E
       1     5    1 2003  2  1  5  60  50   1  1  3.477  3.477   21091.   35301.  16.014 4.457E-
2.713E-03 1.573E-02 1.628E-01 1.967E-01 2.238E-03 6.943E-03 1.343E-01 1.967E-01 6.839E-03 6.930E
       1     6    1 2003  2  1  6  60  50   1  1  3.207  3.207   19452.   24262.  11.006 4.528E-
2.219E-03 1.099E-02 1.332E-01 2.017E-01 1.214E-03 4.893E-03 7.282E-02 2.017E-01 4.640E-03 4.884E
```

Exhibit 5-1. Portion of an Events File.

A portion of an example *Events* file is shown in Figure 5-11 above. This file can become very large, averaging about 1.4 MB per person-year. For this reason, the user is given the option of writing the events for only a fraction of the simulated persons. This is controlled by the *Control* file settings ***EventSample*** and ***CustomSample***. See Section 4.2.3 for more information on these keywords.

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