An Introduction to APEX

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Glossary

Activity diary	A set of events or activities (e.g., cooking, sleeping) for an individual in a given time frame (e.g., a day). The information regarding human activities whose data is stored in the *Diary Events*, *Diary Questionnaire*, and *Diary Statistics* input files. The individual activity diaries described by these input files contain information about the location, length of time, and time of day of an individual's activity, as well as demographic data pertaining to the individual (e.g., sex, race, age, employment status, etc.). This information should be based off of actual human activity studies. These activity diaries are sampled, based on matching demographic data from a profile, to compile a list of activities for each modeled profile that spans the entire simulation duration.
Air quality district	Geographical area represented by a given time series of ambient air quality data (either based on a fixed-site monitor or output from an air quality model).
Air Pollutants Exposure model (APEX)	A multipollutant, population-based, stochastic, microenvironmental model that can be used to estimate human exposure via inhalation for criteria pollutants and air toxics.
CHAD	Consolidated Human Activity Database.
Control Options File (*COF*)	Input file where the user specifies input and output file names and locations and the simulation settings.
Cut points	A set of concentration levels set by the user. APEX will bin all the exposures in the simulation period based on these levels.
Deterministic model	A model that uses point estimates (non-probabilistic values) for input variables to model relationships to produce one resulting value for each output.
District	A geographical area represented by air quality data. See Air quality district.
EPA	United States Environmental Protection Agency.
Event	An activity (e.g., cooking) with a known starting time, duration, microenvironment, and location (usually home or work).
Keyword	Text to the left of an equal sign in the *Control Options* file that name specific variables that APEX is searching for in the file. The keyword defines the variable (input file path, output file path, or parameter), and the text to the right of the equals sign is the value attributed to this keyword. Keywords, as well as the values assigned to them, are not case sensitive.
Meteorological zone	The geographical area represented by a given time series of meteorological data (either based on a meteorological station or output from a meteorological model).

Microenvironment	A space which has a relatively homogeneous air pollution concentration and in which human contact with an environmental pollutant takes place. A defined space for which the air pollutant concentration is roughly homogeneous throughout. Profiles inside of a microenvironment (e.g., "indoor kitchen", "in vehicle", etc.) are exposed to a pollutant concentration derived from the ambient pollutant concentration and parameters that modify this pollutant concentration inside the microenvironment (specific to each microenvironment and pollutant).
National Ambient Air Quality Standards (NAAQS)	Air quality standards set by the U.S. Environmental Protection Agency for pollutants considered harmful to public health and the environment.
Persons	Users may run an APEX simulation with 10,000 "profiles", and the results of this can be related to the "persons" of the entire population (which may be on the order of millions). "Persons" should reflect the number of people in a given category in the APEX study area. Generally, "persons" are a scaled-up version of "profiles."
PM	Particulate matter.
Population-based model	A model that simulates multiple people that collectively form a representative sample of a population (or population subgroup) rather than a single person in a specified scenario.
Probabilistic model	A model that samples input parameters from a probability distribution of all possible input values and produces a distribution of output values.
Profile	The representation of a single simulated human in APEX. A set of characteristics that describe the person being simulated (e.g., age, sex, height, weight, employment status, whether an owner of a gas stove or air conditioner). These characteristics may affect their activities, their locations, or the concentrations in the microenvironments that they encounter.
Sector	The basic geographical unit for the demographic input to and output from APEX (usually census tracts). All demographic data (e.g., population, employment, commuting, disease prevalence, etc.) must be aggregated on the basis of these geographic sectors. Note that while the data aggregated on the basis of a sector should correspond to a closed geographical region, APEX only recognizes sectors by their geographical centroids.
Study area	The geographical area modeled in a simulation.
Study area population	Total population of persons who live in the study area.
Timestep	The time resolution of the input air concentration and of the simulated run. The user can specify the timestep of the output (5 minutes, 1 hour, 8 hours, 24 hours), however APEX can only output the smallest timestep provided in the air concentration file.
UG1 and UG2	The APEX Version 5 User's Guides Volumes I and II.
Zone	The area covered by a meteorological station. See Meteorological zone.

1. Purpose of this Introductory Document

This introductory document is for those relatively new to the EPA's Air Pollutants Exposure model (APEX) or stochastic inhalation exposure modeling in general. APEX is a multipollutant, population-based, stochastic, microenvironmental model that primarily estimates human exposure via inhalation to criteria pollutants and air toxics. This introduction should begin to answer questions such as those listed below.

- What is stochastic, population-based inhalation exposure modeling?
- What is APEX?
- Is APEX well suited for your needs?
- Do you have enough information, time, and experience to run APEX?
- What steps are involved in a typical APEX run?
- What steps are involved in a more complex APEX run with user-tailored inputs and settings?
- How do you interpret basic APEX outputs?

Most people should be able to run a pre-configured, typical APEX test case (the APEX website[1] provides a test case for users to download) and interpret some of its outputs after reading this document.

This introductory document is not a substitute for the more comprehensive APEX User's Guide (Volumes 1 and 2) (US EPA Office of Air Quality Planning and Standards, 2019a, 2019b). This document frequently references the User's Guide, as it is meant to serve as an introduction to the User's Guide. (The citation convention used throughout this document is "UG1" and "UG2" to differentiate between User's Guide Volume 1 and Volume 2.) Users seeking more detailed information about APEX and its inputs, algorithms, and outputs should refer to the APEX User's Guide.

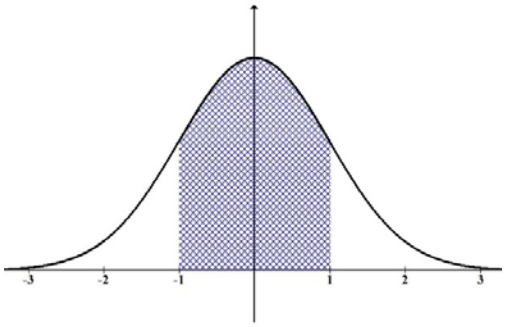
[1] APEX website: https://www.epa.gov/fera/human-exposure-modeling-air-pollutants-exposure-model.

2. Background Information

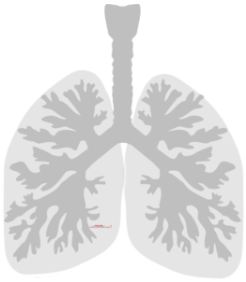
2.1. Overview of Population-based, Probabilistic Inhalation Exposure Modeling

APEX is a population-based, probabilistic inhalation exposure model. It samples simulated individuals from a geographic area who go about typical daily activities to determine their inhalation exposure to a particular air pollutant over a period of time.

A **population-based model** means that the model simulates multiple people rather than a single person in a specified scenario. The model examines a large group of individuals by creating demographic profiles, sampled from a range of possible demographic characteristics, to generate a representative sample of modeled individuals in a particular geographic area. The term “profile” is used throughout APEX documentation to refer to hypothetical individuals modeled in APEX. The individual profiles created in APEX do not map to real individuals from an actual study.



APEX is a **probabilistic model** in that it creates simulated persons and exposure environments from probabilistic distributions of input parameters, such as population demographics, physiological attributes, and activities. Probabilistic models are well suited for stochastic processes since they incorporate variability in the input parameters. For each random variable, the range of possible values is entered into the model as a probability distribution. The model then randomly selects which value to use for each input parameter based on the probability distribution associated with each parameter. A probabilistic model can produce a different output with every run since different input parameter values may be selected each time. Typically, a probabilistic model provides a probability distribution of outputs. In contrast, a deterministic model uses point estimates (single values) for input variables to model relationships and produces one resulting value for each output.



Finally, APEX is an **inhalation exposure model**, meaning it only considers the inhalational route of exposure (pollutants in the air that a person breathes in). Pollutants can also be transported in other media (water, sediment, dust, etc.) and enter a person through different exposure routes (dermal or ingestion). The model uses temporally and spatially varying ambient air concentration data, along with information about the behavior of the pollutant in different settings (microenvironments), to estimate the air concentrations of the pollutant in microenvironments, and it then estimates exposure/internal doses (in the simulated individuals) under various settings by using the activity patterns/physiological variables of each simulated individual.

2.2. Overview of APEX

APEX estimates human inhalation exposure to criteria pollutants and air toxics at the local, urban, or regional level. There are seven broad steps in the APEX model, as described briefly in Figure 2-1 and illustrated and described with more detail in Figure 2-3–Figure 2-9. These figures are overviews; for a more comprehensive understanding of these steps, refer to Section 3 and UG1 and UG2.

1	Characterize study area	APEX models sectors within a study area corresponding to Census data
2	Generate simulated profiles	APEX stochastically generates a set of profiles based on the demographics of the study area
3	Construct activity events	For each profile, APEX constructs an activity diary for each day in the simulation
4	Estimate energy expenditures	APEX constructs energy expenditures for each profile based on activity sequence
5	Calculate concentrations in ME	Based on air quality input data, APEX calculates the pollutant air concentration in each microenvironment (ME) in each air quality sector, for each timestep, for the period of the simulation
6	Calculate exposures for each pollutant	APEX assigns a concentration to each exposure event based on the location of the activity
7	Calculate doses	APEX optionally calculates dose values for each of the simulated individuals, for each timestep

Figure 2-1. Overview of Process Steps in APEX

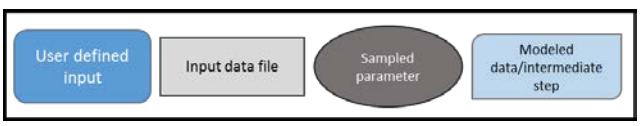
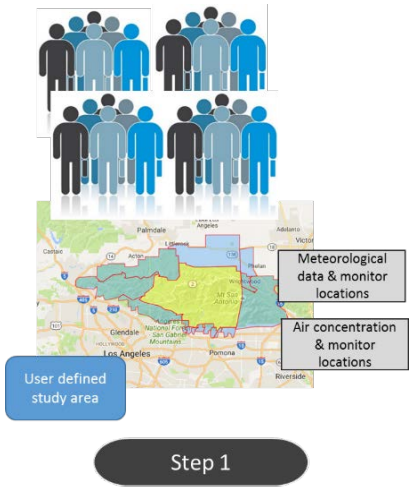
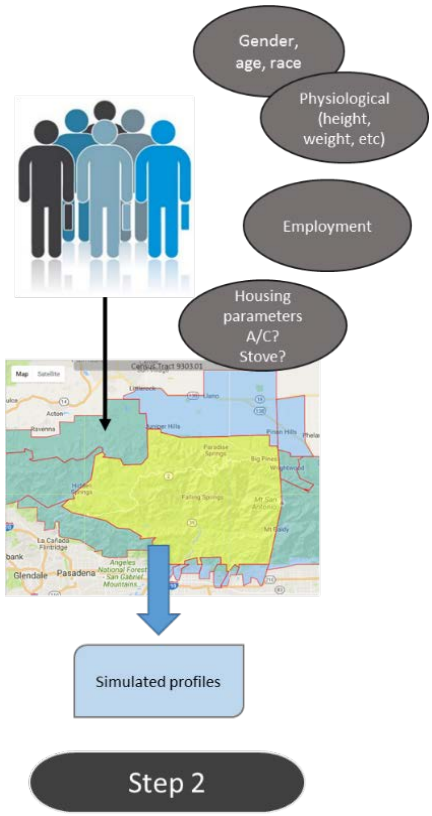


Figure 2-2. Legend for APEX Overview Figures (Figure 2-3–Figure 2-9)



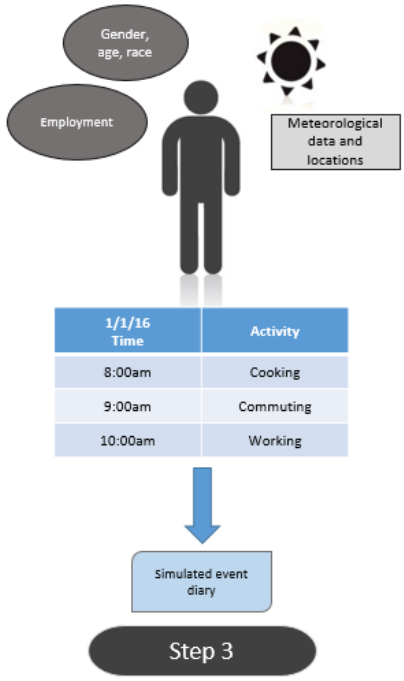
In the first step, the user defines the study area, the time period of interest, and specifies the number of profiles to be used in the simulation. The number of profiles should be large enough to provide a representative sample of people in the area. The user must also provide input data on air concentrations and meteorology data for the study area.

Figure 2-3. APEX General Step 1



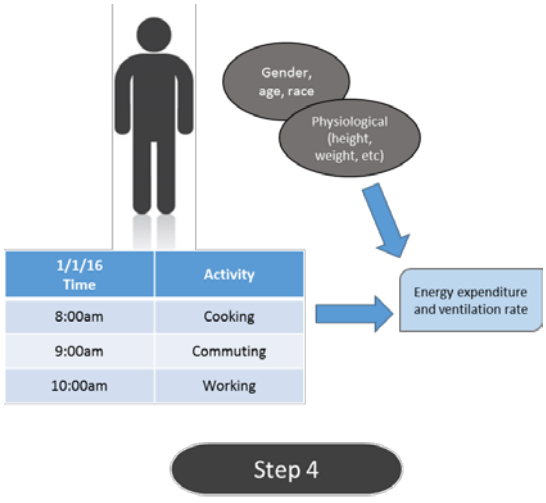
The model then generates a representative, random sample of simulated people with sex, age, and racial characteristics in proportion to those within the study area, by default based on U.S. Census Data. APEX randomly selects each simulated individual's physiological attributes (height, weight, etc.) based on age- and sex-specific probability distributions. Employment status of each person is assigned based on employment probabilities for the given study area. APEX also assigns each simulated person housing parameters such as whether they have air conditioning and gas stoves based on probability distributions. Finally, APEX assigns each simulated person a home location and a work location if employed.

Figure 2-4. APEX General Step 2



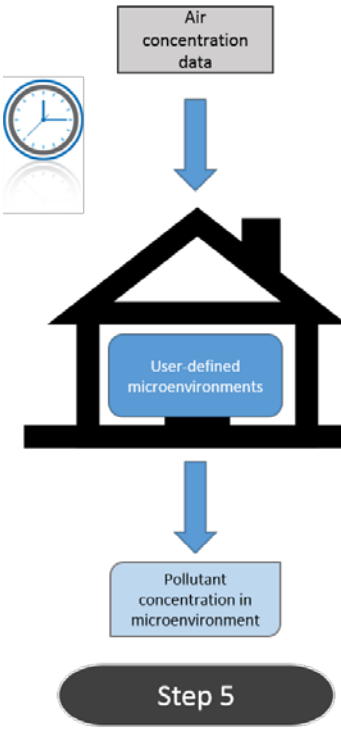
Next, the model generates an activity diary for each simulated individual for every day of the simulation. The activity patterns of the simulated individuals are assumed by the model to be comparable to those of individuals with similar demographic characteristics, according to activity data such as diaries compiled in EPA's Consolidated Human Activities Database (CHAD) (US EPA, 2019c; McCurdy et al., 2000). Simulated demographic information along with the time period of the simulation and input weather data are used by the model to sample activity diaries for each simulated person for each study day.

Figure 2-5. APEX General Step 3



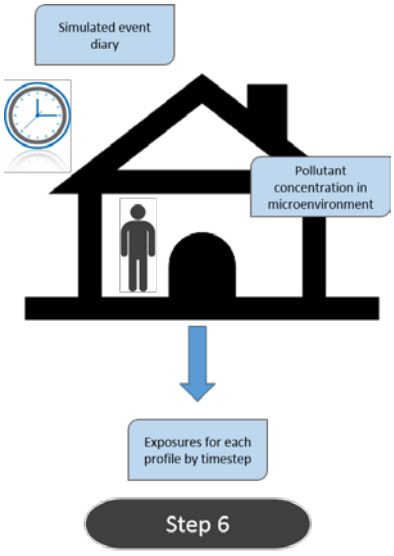
The model then estimates the energy expenditure and resulting ventilation rate of each activity for each simulated individual based on his or her demographic and physiological variables (age, height, weight, resting metabolic rate, etc.).

Figure 2-6. APEX General Step 4



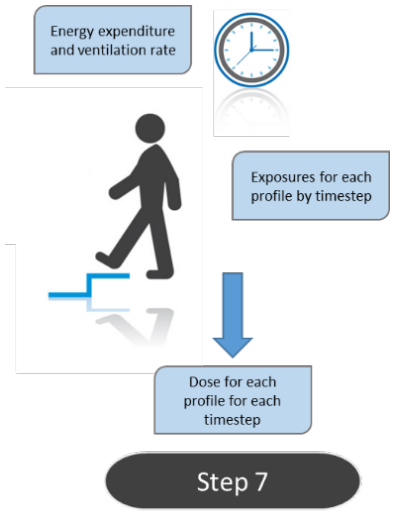
For each simulation, the user defines microenvironments, which are different spaces with relatively homogeneous air pollution concentrations in which activities takes place. Typical microenvironments may include indoor spaces such as residences or offices and outdoor areas like parks. APEX uses the input ambient concentrations of pollutants to calculate the concentration for each pollutant in every microenvironment for every timestep. Every activity included in the activity diaries is mapped to a microenvironment, however the calculations of pollutant concentration in microenvironments occur independently of simulated profiles and their activities (that is, APEX will calculate timestep concentrations in microenvironments regardless of if a simulated individual occupies that microenvironment in that timestep).

Figure 2-7. APEX General Step 5



Next, APEX calculates the inhalation exposure for simulated individuals for each timestep based on the activity location, activity duration within the microenvironment, and microenvironment pollutant concentration.

Figure 2-8. APEX General Step 6



Finally, the model uses the ventilation rate associated with a simulated profile and the exposure metrics to calculate the inhaled dose for each simulated individual as a function of timestep.

Figure 2-9. APEX General Step 7

Each of these seven steps will be covered in more detail in later sections.

2.3. Is APEX Well-suited for Your Needs, Experience Level, and Resources?

2.3.1. Is APEX Appropriate for My Application?

Users will want to consider if APEX is the appropriate tool to use for their particular application. It is typically appropriate to use APEX for the applications listed below.

- Metropolitan or smaller areas
- Assessing acute and chronic inhalation exposure to pollutants originating outdoors and/or indoors
- Assessing exposure for a variety of age groups and other subpopulations spending time in customizable microenvironments

It is not appropriate to use APEX for the applications listed below.

- Areas larger than single (Eastern) states
- Estimating outdoor ambient air concentrations
- Assessing dermal or ingestion exposures
- Estimating exposures and doses for specific, real people

- Modeling chemical interactions between pollutants

A more in-depth discussion of APEX's strengths and weaknesses may be found in UG1, Section 1.3.

2.3.2. Who Should Use APEX?

APEX is a sophisticated exposure model that utilizes multiple, detailed input files. It is not recommended that a novice in the field of modeling begin with APEX. Users should have basic experience in air quality analysis and be familiar with probabilistic modeling.

While users do not need to have a background in programming languages, the model does not have a graphical user interface. Adjustments and user specifications are defined in a plain text *Control Options* file (*COF*), and APEX is run in a PowerShell window. All input files must be in text format (.txt) and users will need to format their input files correctly in order for the model to read the data. The User's Guide provides detailed instructions on preparation of input files. All output files also are in text format, therefore users may desire to use other programs to process the files into other file formats or into user-customized summaries. Post-processing scripts for SAS and R are included in the Appendix to this document, but users will need some understanding of either SAS or R in order to run the scripts.

2.3.3. What Resources are Required to Run APEX?

Even for those familiar with modeling, APEX requires a sizable time investment to learn the model, set up a run, and execute a run. It is not a model one can learn overnight and users will need to allot sufficient time to study the User's Guide in order to use the model appropriately for applications other than the examples provided in this document.

APEX is a very data-intensive model, and users will want to review the required input data files to evaluate if they are able to obtain all the required inputs to run the model for their purposes. Users will need to identify and format multiple input files. Due to the volume of input data that APEX reads and the internal algorithms that APEX runs, the typical APEX runtime is multiple hours. The APEX runtime typically scales according to the number of profiles used in the simulation (see Table 2-1).

Table 2-1. Estimated Computational Time Based on Number of Profiles for a 365-day Simulation with 1-hour Timesteps

Number of Profiles	Estimated Computational Time (hours)
100	0.05
10,000	1.1
100,000	11

2.3.3.1. System Requirements

APEX is written in Fortran using only standard routines and conventions to allow portability to different operating systems and compilers. APEX has been tested on Windows 10, 7, Vista, XP,

2000, NT, and 98 operating systems, as well as Linux, using Intel Fortran. Other compilers may produce warnings and/or errors and may require some small code changes for compatibility. APEX currently uses ASCII coding.

- The recommended minimum system properties are
  - 2 GB of RAM,
  - 600 MHz processor, and
  - 1000 MB of available hard drive space.

The input files supplied with APEX will require at least 500 MB of hard drive space, and the additional input files created by the user may take up another 1–10 MB of space, or more, depending mainly on the size of the air quality input files.

2.4. Previous Applications of APEX

In order to protect human health, the EPA develops National Ambient Air Quality Standards (NAAQS) for certain air pollutants. Under the Clean Air Act, the EPA is required to periodically review the NAAQS. The multi-step review process typically includes a risk and exposure assessment to characterize exposures and the associated risk resulting from ambient air concentrations of the specific pollutant. In recent years, the EPA has used the APEX model as part of the risk and exposure assessment to review the NAAQS for ozone (Appendix 3D of US EPA, 2020), nitrogen dioxide (US EPA, 2008), sulfur dioxide (US EPA, 2018), and carbon monoxide (US EPA, 2010).

For each of the assessments, APEX was run using air quality data based on status quo conditions, air quality data adjusted to meet current air quality standards, and air quality adjusted to meet other potential standards. This application informed regulators in determining how effective new NAAQS levels would be in reducing the public health risk associated with the pollutants.

In the reviews, the EPA considered vulnerable subpopulations in order to set a standard that is sufficiently conservative to protect their health in addition to the greater population. The APEX models for the NAAQS reviews incorporated asthma prevalence data in order to assess the risk associated with asthmatic children and asthmatics of all ages.

A brief overview of the study area(s), year(s) simulated, and population analyzed in four applications is provided in Table 2-2.

Table 2-2. Study Area(s), Year(s) Simulated, and Population Analyzed for NAAQS Reviews using APEX

Assessment	Study area(s)	Year(s) Simulated	Population Analyzed
Ozone (US EPA, 2020)	Atlanta, Georgia Boston, Massachusetts Dallas, Texas Detroit, Michigan Philadelphia, Pennsylvania Phoenix, Arizona Sacramento, California St. Louis, Missouri	2015, 2016, 2017[a]	General population School-aged children (5–18 years)
Nitrogen dioxide (US EPA, 2008)	Atlanta, Georgia	2001–2003	General population School-aged children (5–18 years) Asthmatic school-aged children (5–18 years) All asthmatics
Sulfur dioxide (US EPA, 2018)	Fall River, Massachusetts Indianapolis, Indiana Tulsa, Oklahoma	2011–2013	General population Asthmatic school-aged children (5–18 years) All asthmatics
Carbon Monoxide (US EPA, 2010)	Denver, Colorado Los Angeles, California	Denver 1995, 2006 LA 1997, 2006	Adults with coronary heart disease

[a]Time periods simulated were ozone seasons, which varied by study area.

3. Running APEX

This section presents a brief summary of the various input files and parameters required for running APEX, as well as a step-by-step tutorial of how to perform an example APEX run. After reading this section, users should have a basic understanding of the files that are required to run APEX, how to modify the more basic parameters in APEX to tailor a model run to their needs, and how to execute an APEX run on their computer. For additional information on the files and parameters discussed in this section, as well as information on the specific format required for all of the input files, refer to the APEX User's Guide Volumes 1 and 2 (US EPA Office of Air Quality Planning and Standards, 2019a, 2019b), referred to as UG1 and UG2, respectively, throughout.

3.1. Downloading APEX

Downloading APEX is a one-time process. An executable file can be downloaded from the APEX website that will install an APEX folder containing all of the necessary files to run the model, as well as supporting documentation and supplementary input files. Figure 3-1 outlines the steps involved in downloading APEX.

After navigating to the EPA's website, users should click "APEX 5.2 installer for Windows" link to download the APEX installation executable. Users may be prompted to specify where to download the installer, or the installer may download to the user's default downloads directory (the installer's location will not impact the APEX installation process). Once the installer has finished downloading, navigate to the directory to which it was downloaded and double click it to launch the installation process. Users may be prompted whether or not they want to allow the APEX installer to make changes to their computer. Click "Yes" to continue installing APEX. On the "Select Destination Location" page, define the directory to which the APEX folder will be installed. It is suggested that users install the folder to the directory "C:\APEX" (this is the default directory specified in the installer) as it will make running the example APEX run easier (see Section 3.3). After defining the installation directory, click "Next". On the "Ready to Install" page, the directory to which APEX will be installed will be displayed under "Destination location:". Click "Install" to begin the APEX installation process. A progress bar will indicate the progression of the installation process. Once the installation is complete, users will see a page entitled "Completing the APEX Setup Wizard". Click "Finish" to complete the APEX installation, and the installer will close.

Note that if APEX has previously been installed on a user's computer, users can overwrite the previous installation of APEX to that same directory or choose to install APEX to a different location on their computer. If users choose to overwrite the previous installation of APEX, the installer will warn them that "The Folder: [directory] already exists. Would you like to install to that folder anyway?" Selecting "Yes" will re-download APEX to the location it was previously downloaded, and all of the files that exist in the APEX directories with names that match the file names of the incoming installation (i.e., all the files that have their original names) will be overwritten. If, however, users have generated new files with different names in the existing

folders or additional folders in the “APEX” directory, these files and folders will not be overwritten with the re-installation of APEX.

Navigate to the directory to which APEX was installed (recall the default is “C:\APEX”). Seven folders should be present in the “APEX” folder as well as two files named “unins000.*”. The file “unins000.exe” can be used to uninstall APEX from a user’s computer. The seven folders contain various files associated with APEX (briefly explained below):

- Documentation folder: Contains the current document as well as Volumes 1 and 2 of the APEX User’s Guides (UG1 and UG2)
- Example_run folder: Contains some of the files associated with the example APEX run presented in Section 3.3, including the Control Options file (*COF*)
- Executables folder: Contains two different APEX executable files (one for 32-bit and one for 64-bit Windows computers) which are used for running the model
- Miscellaneous folder: Contains supplemental files for more advanced APEX runs
- NationalDefaultDatabases folder: Contains data files for various national datasets (e.g., population, human physiological parameters, etc.), some of which are used in the APEX example run
- Output folder: The output directory for the example APEX run explained in Section 3.3 (this folder is empty upon installation)
- SourceCode folder: Contains the Fortran source code that is used to generate the APEX executable files

Navigate to the Example_run folder. A file named cof_example.txt is the *Control Options* file (*COF*). This is the file where the user specifies the settings and files that will be used in an APEX model run (see Sections 3.2 and 3.3). Several input files for the example APEX run are found in this Example_run folder, and the remaining files for the example run are found in the NationalDefaultDatabases folder (see Section 3.3 for details).

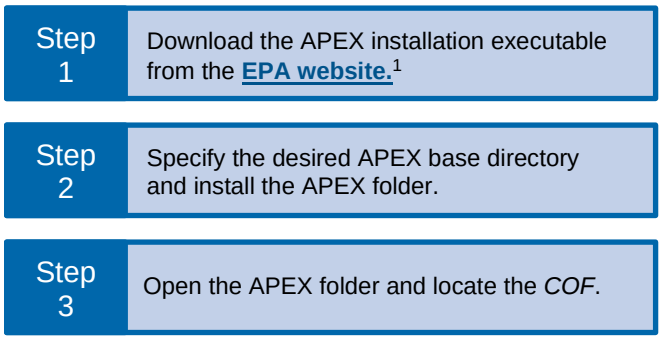


Figure 3-1. Steps for Downloading APEX

3.2. APEX Inputs

The files extracted from the APEX installer include the *COF* as well as examples of the various air quality, meteorological, demographic, physiological, human activity, etc. input files necessary to run APEX.

Table 3-1 provides information pertaining to the *COF* and the other input files included in the APEX download (specifically the Example_run and NationalDefaultDatabases folders). The contents of the table are described below.

- Input File Description: The name of the input file, as it is referred to throughout the document
- Name of File in Example Run: The name of the file from the APEX download
- Control File Keyword: The variable name that is attributed to each input file in the *COF*
- Required: Denotes whether or not the input file is necessary for an APEX run
- Required User Action: Denotes what, if any, action is required on the user's part to prepare the input file
- Pollutant Specific: Establishes whether the input file contains information that applies only to a given pollutant. Any input files denoted as being pollutant specific must have separate files for each pollutant being modeled
- Spatial Scale: Defines the geographical area for which the input file is relevant

Further explanation regarding how these files must be properly configured for an APEX run can be found in Section 3.2.1, and an exhaustive discussion on this topic can be found in Section 4 of UG1.

Table 3-1. List of APEX Input Files

Input File Description	Name of File in Example Run	Control File Keyword	Required	Required User Action[a]	Pollutant Specific	Spatial Scale
Control Options file	cof_example.txt	-	Y	M	N	NA
Air Quality Data	AQ_concs_Ozone_2010_LA.txt	*Air Quality file, Ozone*	Y	P	Y	Study area specific
Air District Location	AQ_districts_Ozone_2010_LA.txt	*Districts file*	Y	P	N	Study area specific
Meteorology Data	Meteorology_data_2010_LA.txt	*Meteorology file*	Y	P	N	Study area specific
Meteorology Zone Location	Meteorology_zones_2010_LA.txt	*Zones file*	Y	P	N	Study area specific
Profile Functions	Profile_functions.txt	*Functions file*	Y	M	N	Study area specific
Microenvironment Descriptions	Microenvironment_descriptions_05_MEs.txt	*Microenvironment file*	Y	M	N	Universal
Microenvironment Mapping	Microenvironment_mappings_05_MEs.txt	*MEMap file*	Y	M	N	Universal
Diary Events	CHAD_diaries_events.txt	*DiaryEvent file*	Y	N	N	National (provided)
Diary Questionnaire	CHAD_diaries_questionnaire.txt	*DiaryQuest file*	Y	N	N	National (provided)
Diary Statistics	CHAD_diaries_statistics_outdoor.txt	*DiaryStat file*	Y[b]	N	N	National (provided)
MET Distributions	MET_distributions_092915.txt	*MET Distribution file*	Y	N	N	Universal (provided)
MET Mapping	MET_mapping_071018.txt	*METMap file*	Y	N	N	Universal (provided)
Physiological Parameters	Physiology080519.txt	*Physiology file*	Y	N	N	Universal (provided)
Ventilation	Ventilation_062117.txt	*Ventilation file*	Y	N	N	Universal (provided)
Prevalence	Disease_prevalence_data_asthma_LA.txt	*Prevalence file*	N	P	N	Study area specific

Input File Description	Name of File in Example Run	Control File Keyword	Required	Required User Action[a]	Pollutant Specific	Spatial Scale
Population Data (must be split between female and male, can also be split by race)	Population_female_Asian_2010.txt Population_female_Black_2010.txt Population_female_Hispanic_2010.txt Population_female_Native_American_2010.txt Population_female_Other_2010.txt Population_female_White_2010.txt Population_male_Asian_2010.txt Population_male_Black_2010.txt Population_male_Hispanic_2010.txt Population_male_Native_American_2010.txt Population_male_Other_2010.txt Population_male_White_2010.txt	*Pop file, Female/Male, Race*	Y	N	N	National (for tracts)
Population Sector Location	Population_sectors_US_2010.txt	*sectors file*	Y	N	N	National (for tracts)
Employment Probability	Employment_US_2010.txt	*employment file*	Y	N	N	National (for tracts)
Commuting Flow	Commuting_flow_US_2010.txt	*commuting file*	N	N	N	National (for tracts)
Commuting Time	Commuting_times_US_2010.txt	*commtime file*	N	N	N	National (for tracts)
Seed Offsets and Sobol Grouping	Seed.txt	*Seed file*	Y	M	N	Universal
Profile Factors	N/A	*Profile file*	N	M	N	Study area specific
ME Mapping for Clustering Diary Assembly	N/A	*DiaryCluster file*	N[c]	M	N	Universal
Diary Transitions File	NA	*DiaryTrans file*	N[c]	M	N	Universal
Diary Occupation (DiaryOcc)	N/A	*DiaryOcc file*	N	M	N	Universal

[a]M: Users will need to modify the file. P: Users will need to provide the file. N: The files provided in the APEX download[1] can be used in the applicable geospatial and temporal scenarios (see Section 3.2.1), however in some instances users may wish to provide their own or modify the provided files to suit their needs. Note these required actions are relevant for users conducting their own runs for 2010 U.S. Census-based data. Users conducting the example APEX run in Section 3.3 will only need to modify the *Control Options* file.
[b]The *Diary Statistics* input file is only required if the ***LongitDiary*** parameter is set to **Y**.
[c]The *ME Mapping for Clustering Diary Assembly* and *DiaryTrans* input files are only required if the ***ClusterDiary*** parameter is set to **Y**.

3.2.1. Some Considerations in Setting Up an APEX Run

This section provides some guidance to users in developing a model run in APEX, and it includes descriptions of the roles that the various input files play. This is intended only as a generalized overview. Users should refer to Sections 3 and 4 of UG1 for a complete discussion of the aspects discussed here and details on the specific formatting required for all input files.

Note that in the following sections, many binary variables are discussed that can be set to a value of either "Yes" or "No" in the *COF* to switch the functionalities of the variables on or off. While APEX is not case-sensitive with respect to the way these variables are set and interprets "Yes" in the same way as "Y" (or similarly "No" the same way as "N"), for consistency throughout the document the convention of **Y** and **N** will be used for "Yes" and "No".

3.2.1.1. Spatial Resolution (*Population Sector Location* File, Various *COF* Parameters)

The geographical spatial units that APEX uses as the basis for its calculations are referred to as sectors. The default input file downloads from the APEX website use sectors defined as 2010 U.S. Census tracts (see the NationalDefaultDatabases folder). Users can, however, define a different geographical unit to be the sectors of analysis (e.g., Census blocks or counties). Figure 3-2, for example, illustrates sectors for the Denver, Colorado region defined as 2010 U.S. Census tracts (panel a) as well as sectors defined as Colorado counties (panel b). The name (arbitrary) and latitude/longitude coordinates (geographic center; i.e., centroid) of each sector are defined in the *Population Sector Location* file. As discussed further in this section, regardless of the geographical definition of the sector, the various population, employment, commuting, and disease prevalence (if applicable) files must provide data aggregated on the basis of these user-defined sectors.

In the *COF*, users also must define the centroid and a radius establishing the area to be modeled (this is done using the ***Latitude***/***Longitude*** and ***CityRadius*** parameters in the *COF*, see Table 3-2). Figure 3-3 provides an illustration of this relationship between sector centroids and the ***Latitude***/***Longitude*** and ***CityRadius*** parameters. Users should note that while the boundaries of the sectors should reflect the way in which the data in the various input files are aggregated, APEX only recognizes the centroid of each sector, and information regarding the geographical boundaries of the sectors is not an input into APEX. For modeled sector centroids, the entire sector is considered to be modeled, while for un-modeled sector centroids, none of the sector is considered to be modeled.

Users can additionally provide a list of specific sectors to analyze (using the ***TractList*** and ***Tract*** parameters), as well as a list of counties (or other geographical unit) in which the sectors must fall in order to be modeled (using the ***CountyList*** and ***County*** parameters) (see Table 3-2). Regardless of the exact definition of the sectors in a model run, a ***County*** is named using the first 5 characters of a sector name, and a ***Tract*** is named using the first 11 characters of a sector name. If the user engages both the ***TractList*** and ***CountyList*** functionalities of APEX, the mathematical union of the two lists will be used to determine the final sectors that are modeled (i.e., the sector must be within one of the counties/other geographical units defined by ***County*** or it must be defined as one of the ***Tracts***).

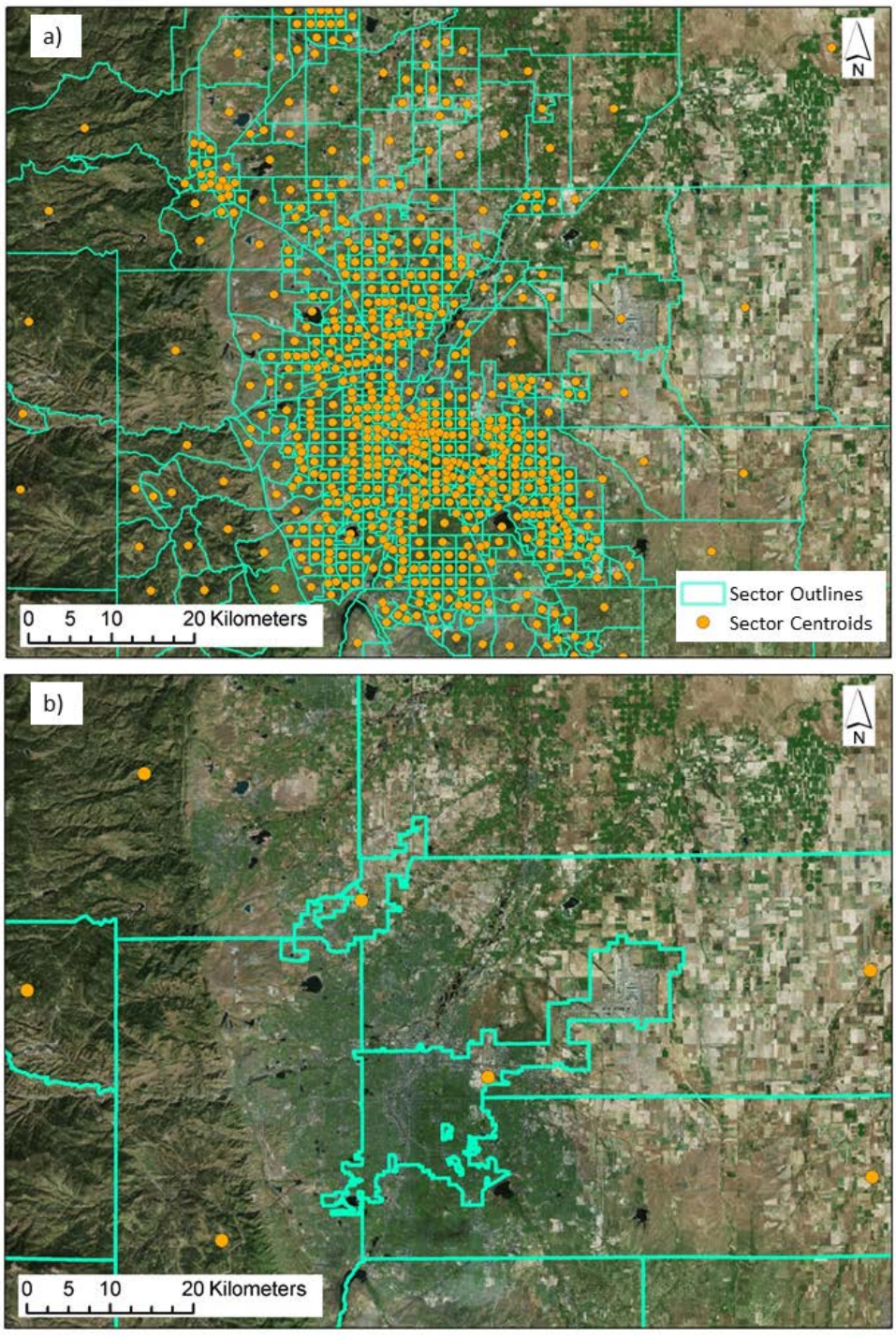


Figure 3-2. Examples of Different Sectors for Denver, Colorado using a) 2010 U.S. Census Tracts and b) Counties

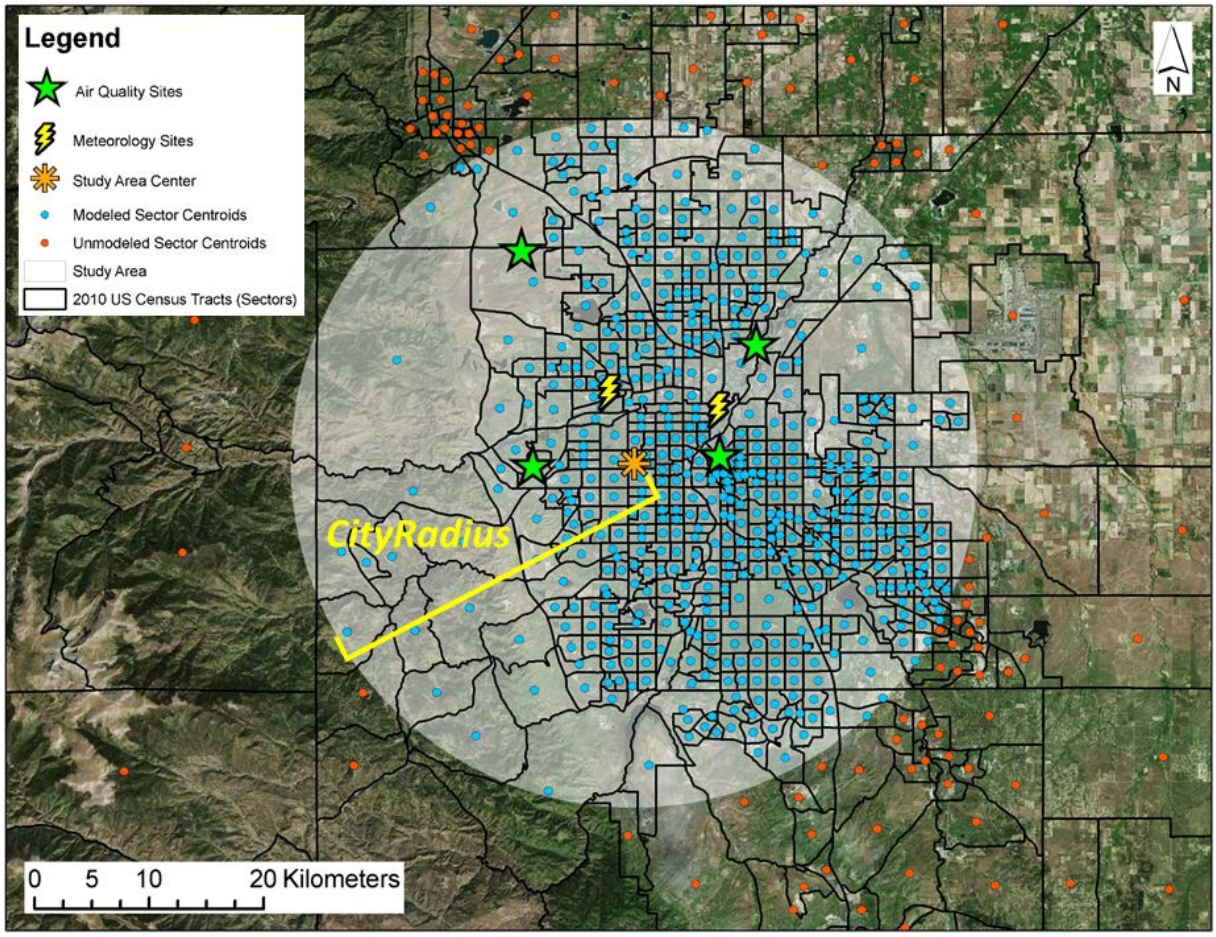


Figure 3-3. Example Demonstration of Latitude/Longitude and City Radius for Denver, Colorado

For a sector to be modeled in APEX, it must meet all of the criteria listed below.

- It falls inside the base study area (i.e., within the ***CityRadius***)
- It falls inside one of the user-defined counties (or other geographical units of interest) in the ***County*** parameter, *or* it is included in the ***Tract*** parameter (these functionalities are optional)
- It falls within an air quality district and a meteorology zone (discussed in Sections 3.2.1.4 and 3.2.1.5, respectively)

3.2.1.2. Demographics (*Population Data, Employment Probability,* and *Profile Factors* Files)

Demographic data defining the race, age, sex, and work status of the population must be provided for each sector (e.g., census tract, county, census block, etc., depending on the user's definition of the sectors).

The default APEX input files provided in the APEX download contain population data for all 2010 U.S. Census tracts in fourteen files (see the NationalDefaultDatabases folder). These files contain population counts broken down by a set of six races (Asian, Hispanic, Black, Native American, White, and Other) and by sex. These *Population Data* files define the number of individuals with these characteristics in each census tract binned by age. Population files that do not break down population counts by race are also provided. While it is not required that these *Population Data* files be broken down by race, these files must specify population data in separate files for males and females.

A separate file, the *Employment Probability* file, defines the fraction of males and females who are employed as a function of sector (i.e., Census tract in the default input downloads file) and age bin.

The optional *Profile Factors* file can be used to specify different factors as a function of race, sex, and sector of the modeled profiles which can then be used to engage microenvironmental scaling factors (see Section 4.12 of UG1).

3.2.1.3. Microenvironments (*Microenvironment Mapping* and *Microenvironment Descriptions* Files)

The *Microenvironment Descriptions* file defines both the names and numbers assigned to each of the microenvironments, and it also defines how the ambient pollutant concentration will be converted to the pollutant concentration experienced in the microenvironment.

The *Microenvironment Mapping* file establishes how the microenvironments defined in the *Microenvironment Descriptions* file will be assigned to the activity locations in the *Diary Events* file (see Section 3.2.1.10).

The installed APEX files from the APEX website provide one set of these files with five microenvironments (see the Example_run folder) and one set with 28 microenvironments (see the Miscellaneous folder; note the example APEX run described in Section 3.3 uses five microenvironments).

The outputs of APEX are highly sensitive to the exact way in which the microenvironments are defined, and so these microenvironment input files will typically need to be modified by users who conduct their own runs. Users who wish to modify the provided microenvironment files are referred to Sections 4.18 and 4.23 of UG1 for a detailed explanation of the file specifications and to Table 8.1 of UG2 for an enumeration of the default mapping behavior of the activity locations in the provided activity diaries files (see Section 3.2.1.10) to the APEX microenvironments.

3.2.1.4. Air Quality (*Air District Location* and *Air Quality Data* Files)

Air quality districts are the geographical units for which air quality data are representative. The center points of these districts are defined in the *Air District Location* file, and their radius of representativeness is defined by either the ***AirRadius*** variable for all districts (see Table 3-2) or individually for each district in the *Air District Location* file (see Section 3.1.3 of UG1). Note that

if the user specifies a value for ***AirRadius*** in the *COF*, this will override any radius defined in the *Air District Location* file.

Pollutant concentrations must be provided by the user for each air quality district centroid in the *Air Quality Data* file. Air quality data for a particular pollutant for all districts is supplied in one file, with separate files providing data for other pollutants. These data must be a continuous time series throughout the entire analysis period (defined by the ***Start_date*** and ***End_date*** parameters; see Table 3-2). Air quality data must be provided for each timestep during the analysis period. The ***TimeStepsPerDay*** variable (see Table 3-2) must match the number of timesteps per day provided in the *Air Quality Data* file. The default for ***TimeStepsPerDay*** variable is 24 (corresponding to hourly air quality data). There must be a whole number of timesteps per day, and additionally, either a whole number of timesteps per hour or a whole number of hours per timestep. Thus, ***TimeStepsPerDay*** must be one of 1, 2, 3, 4, 6, 8, 12, 24, or a multiple of 24, up to 1440. If one or more timestep entries are missing for a district in the *Air Quality Data* file during the analysis period, that air quality district is not modeled. For this reason, users should fill in any missing time steps for an air quality district with an interpolation scheme that best suits their purposes (e.g., temporal, spatial, or interpolation that incorporates a mixture of both). See Sections 4.4 and 4.5 of UG1 for full details on how the *Air District Location* and *Air Quality Data* input files (respectively) must be formatted.

Calendar dates in APEX are specified as 8-digit numbers (integers), using the YYYYMMDD format. For example, January 1, 2017 becomes 20170101. The leading zero is needed when the month or day is a single digit. This format ensures that dates may be sorted either lexically (alphabetically) or numerically, and always come out in chronological order.

In order to map air quality data obtained at the center of the air quality districts to the modeled sectors, each sector is linked to its closest air quality district (as long as it is within the ***AirRadius*** of the air quality district) based on the district and sector centroid locations. Figure 3-4 (panel a) illustrates the spatial relationship between sector centroids and air districts. Any air districts that are not linked to a sector, as well as any sectors that are not linked to an air district, will not be modeled. Figure 3-4 (panel c) plots the sectors that would be modeled in that example, as they are both inside air districts and inside meteorology zones (zones are discussed in Section 3.2.1.5 below). At each timestep of the modeling, each sector is assigned the ambient pollutant concentration of its matching air district (see Section 3.1.3 of UG1).

The example run provided in the APEX download uses air district and air quality data for the Los Angeles, California area for 2010 (see the Example_run folder). Users can download air quality data (with geospatial location information) for other regions and time periods from the EPA here.[2] These files need to be reformatted for input to APEX.

[2] Air quality data files: http://aqsdr1.epa.gov/aqsweb/aqstmp/airdata/download_files.html.

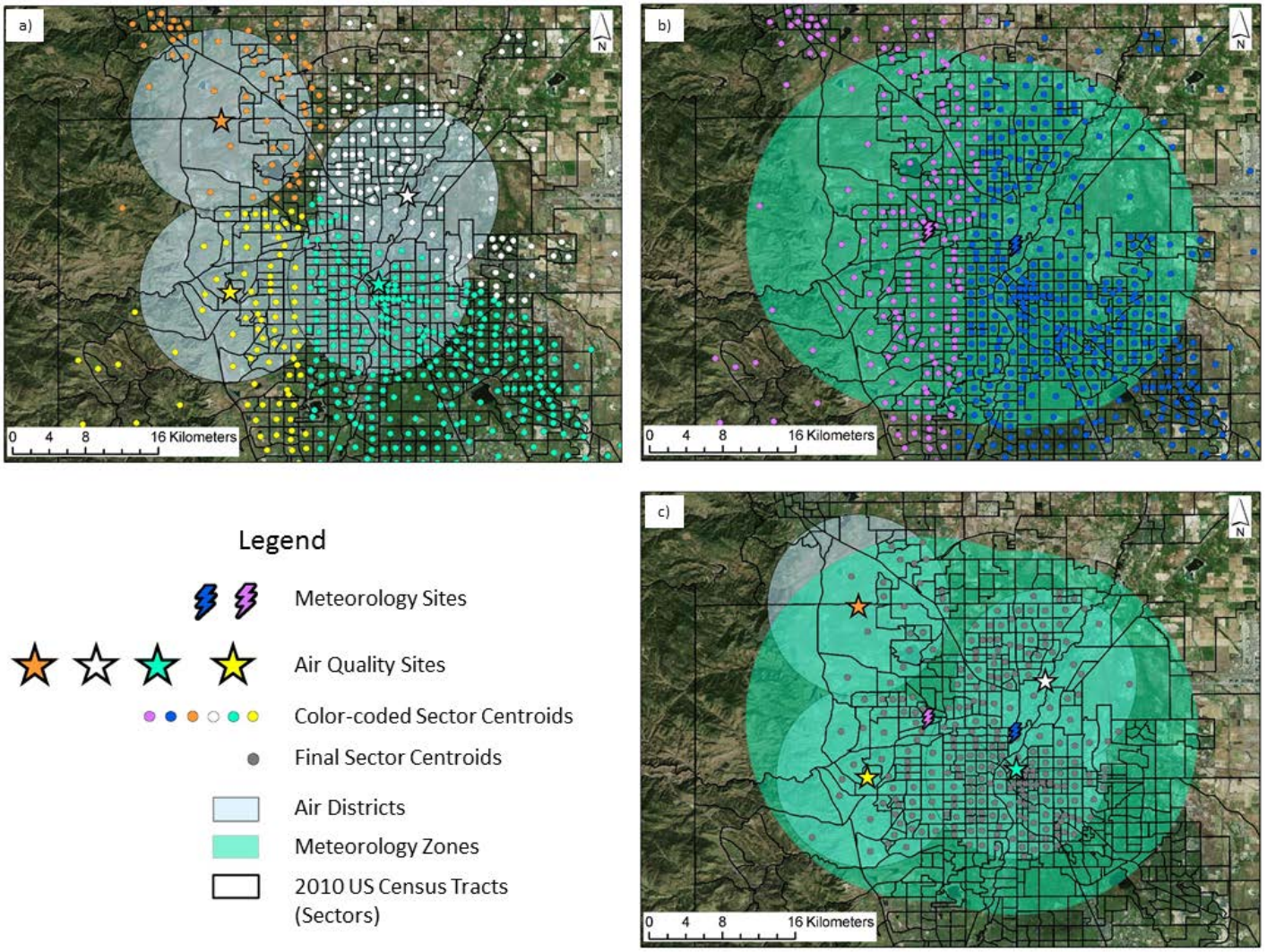


Figure 3-4. Example Relationship between Sectors, Air Districts, and Meteorology Zones for Denver, Colorado

3.2.1.5. Meteorology (*Meteorology Zone Location* and *Meteorology Data* File)

The meteorology zones in APEX are the meteorological equivalent of the air quality districts—they are the geographical units for which the meteorology data are valid. Each zone is defined by a center point in the *Meteorology Zone Location* file and a radius of extent set by the ***ZoneRadius*** variable (see Table 3-2).

Meteorological data, provided in the *Meteorology Data* file, must be a continuous hourly time series for each zone during the period of analysis, and any zone with missing data for one or more hours is not modeled. For this reason, users should fill in any missing time steps for a meteorology zone with an interpolation scheme that best suits their purposes. One *Meteorology Data* file can contain data for multiple meteorology zones.

Each sector is linked to its closest meteorological zone based on the sector and zone centroid locations (as long as the sector centroid is within the radius of the meteorology zone). Figure 3-4 (panel b) illustrates the spatial relationship between sector centroids and zones. Any sectors that cannot be linked to a meteorology zone are not modeled. Figure 3-4 (panel c) plots the sectors that would be modeled in that example, as they are both inside meteorology zones and inside air districts (districts are discussed in Section 3.2.1.4 above). See Sections 4.6 and 4.7 of UG1 for details on the required format of the *Meteorology Zone Location* and *Meteorology Data* files (respectively).

The example run provided in the APEX download uses meteorology data for the Los Angeles, California area for 2010 (see the Example_run folder). Users can download meteorological data (with geospatial location information) for other regions and time periods from the EPA here.[3]

3.2.1.6. Commuting (*Commuting Flow* and *Commuting Time* Files)

The ***Commuting*** parameter is a binary variable that establishes whether or not profiles commute from their home sector to a sector for work (see Table 3-2). If this variable is set to **Y** ("Yes"), the details describing how many individuals commute from their home sector to a work sector (and the commute distance) and distributions of the time lengths of the one-way commutes are described in the *Commuting Flow* and *Commuting Time* files (respectively). These data must be provided on the basis of the same sectors defined in the *Population Sector Location* file.

In the *Commuting Flow* file, each home sector is paired with one or more work sectors, corresponding to profiles living in a home sector and commuting to these work sectors. The file provides a cumulative fraction of the population from the home sector commuting to each of the work sectors, and it also provides the commute distances between sector centroids (see Section 4.9 of UG1).

The *Commuting Time* file defines the total number of workers in each home sector (including how many work at home or away from home) and the numbers of workers whose commute times fit into one of several commute-time categories (one-way times) (see Section 4.10 of UG1).

[3] http://aqsdr1.epa.gov/aqsweb/aqstmp/airdata/download_files.html

The *Commuting Flow* and *Commuting Time* files provided in the APEX download are based on 2010 U.S. Census tracts (see the NationalDefaultDatabases folder). Users interested in generating their own *Commuting Flow* and *Commuting Time* files are directed to Sections 4.9 and 4.10 of UG1 and Section 4.3 of UG2 for details on the required structure of these files.

3.2.1.7. Disease (*Prevalence* File)

APEX has the optional capability to extract data for the subset of profiles in the modeling domain that have a particular disease, using the *Prevalence* file. This file defines the probability that individuals in each of the sectors have the modeled disease, binned by age and sex. APEX does not model profiles with a disease differently from profiles without a disease (i.e., a profile having or not having a disease does not impact pollutant exposure or dose). Instead, this capability in APEX simply creates a separate set of outputs (i.e., those profiles with the disease) that is a random sample of all modeled individuals, based on user-supplied disease prevalence rates. Pollutant exposure and dose can then be analyzed as a function of profiles with or without the given disease.

This functionality is set using the ***Disease*** variable in the *COF* (see Table 3-2). If this variable defining the disease is set, the corresponding *Prevalence* file must be supplied by the user. APEX will randomly assign an indicator to each profile denoting whether or not the individual has the disease. Note that disease probabilities have to be defined for both sexes and all ages from 0 to 99 (see Section 4.24 of UG1 for details on the required format of the file). In the example APEX run described in Section 3.3, asthma is the modeled disease. Note also that in this example APEX run, we use asthma data for Los Angeles only (see the Example_run folder). Users wishing to use asthma data in a different area must supply their own data.

The concept behind the use of this variable is that the disease rate may vary by location, in a manner that is correlated with exposure, if there is an association between the two. In principle, the prevalence does not have to represent an actual disease, but rather any spatially varying probability that is expected to be associated with air quality or airborne exposure.

3.2.1.8. Conditional Variables (*Profile Functions* File)

The *Profile Functions* file sets up conditional variables and defines the diary pools. For example, the choice of distribution of air exchange rates can depend on the presence or absence of an air conditioning (AC) unit can impact how individuals are exposed to pollutants. The probabilities of an individual in a sector having an AC unit in their home or car can be defined in the *Profile Functions* file as the variables AC_Home and AC_Car. See Section 5.2 of UG2 for a brief discussion of these variables and Section 4.17 of UG1 for a detailed discussion of how the profile functions are defined. Note that information in this file can be provided for the modeled population in general or on the basis of sectors.

3.2.1.9. Physiology Specifications (*Physiological Parameters* and *Ventilation* Files)

The *Physiological Parameters* file contains distributions of various physiological parameters (including body mass, height, resting metabolic rate, blood hemoglobin density, etc.) on the basis of age and sex. The file included in the APEX download contains distributions of these

parameters (for the U.S. population) from literature and government databases, and it generally should not need to be modified (see Section 4.15 of UG1).

Similarly, the provided *Ventilation* file contains regression parameters (for the U.S. population) used by APEX to estimate ventilation quantities, and it should not be modified except by advanced APEX users (see Section 4.16 of UG1). Unlike the *Population Data* files (among others), the data in the *Physiological Parameters* and *Ventilation* files are not provided on the basis of sector, but rather they apply generally to the given modeled population (see the NationalDefaultDatabases folder).

3.2.1.10. Activity Diaries (*DiaryQuest, DiaryEvent, DiaryStat, MET Mapping* and *MET Distributions* Files)

APEX uses human activity data, referred to as activity diaries, in order to construct a representative series of events or activities that a modeled profile carries out for the duration of the simulation period. This is done to capture a representative spectrum of typical human activity, on the basis of age, sex, employment, etc., during which exposure to pollutants can occur.

The *DiaryQuest*, *DiaryEvent*, and *DiaryStat* files all contain information on activity diaries on the basis of age, race, and other demographics. These activity diary files are sampled by APEX based on the model-generated characteristics of each profile, creating sequences of location-specific activities for each profile that are representative of an individual that is demographically similar to the modeled profile.

The *MET Mapping* and *MET Distributions* files define the way in which each activity is translated in APEX to energy expenditure and ventilation rate.

Coupled with MET and microenvironment information, the activity diaries help define profile exposure to the modeled pollutant(s) at each timestep. These files in the APEX download provide data based on CHAD (EPA, 2019c; McCurdy et al., 2000, see the NationalDefaultDatabases folder). These files should generally not need to be modified by APEX users. See Sections 4.19–4.21 of UG1 for further details on the activity diary files and how to create user-generated activity diary files, and Sections 4.13 and 4.14 of UG1 for details on the MET files.

3.2.1.11. Random Seeds (*Seed Offsets and Sobol Grouping* File)

The *Seed Offsets and Sobol Grouping* file contains offsets for random number seeds on the basis of different variables. The Sobol grouping numbers in this file are also used if ***SobolRun*** is set to **Y** in the *COF* (i.e., if a Sobol sensitivity analysis is being performed; see Table 3-2). This is a fairly advanced functionality of APEX, and users should refer to Section 11 of UG2 for details regarding Sobol sensitivity analysis.

3.2.2. Input Parameters

This subsection provides a brief line-by-line explanation of selected input parameters for an APEX model run. Figure 3-5 through Figure 3-10 display the input parameters as they are

defined in the *COF* for the example APEX model run in the APEX download (see the Example_run folder); information about each of these parameters, as well as the line number of each parameter in Figure 3-5 through Figure 3-10, is provided in Table 3-2.
Where possible, the APEX input parameters have been grouped in the *COF* as being “basic” or “advanced” parameters. Basic parameters are those that a novice modeler might want to customize or that might be customized in a typical APEX run. Advanced parameters are those that an experienced modeler might want to customize or that might be customized in a more complex and unusual APEX run. Emphasis is put on describing the basic parameters in Table 3-2; a brief explanation of the advanced parameters is provided here, but Tables 3-3 and 4-4 of UG1 provide an in-depth discussion of all of the basic and advanced input parameters. Users should also note that there may be a handful of instances where a given parameter is addressed by a slightly different name between this document and UG1 or UG2 (e.g., ***RBbackgnd*** in this document versus ***RbBack*** in UG1). In instances like this, either parameter name should be acceptable to use in the *COF*.

Table 3-2. Selected APEX *Control Options* File Parameters

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
Study Area Parameters (Basic)							
Scenario	2	N	Character string describing the modeling scenario outlined in the *COF*. This parameter is used only for labeling purposes, and it is not used internally in APEX. This appears in the header records of all output files.	Character	-	-	Up to 40 characters
#profiles	69	Y	A positive integer defining the number of individuals (i.e., number of profiles) being modeled in the APEX run. Note that APEX runtime and memory requirements will increase as the number of profiles increases.	Integer	Profiles	-	Will depend on computer specifications. Typically 10,000 to 100,000.
Location	70	N	A brief text description of the area being modeled. This parameter is used only for labeling purposes, and it is not used internally in APEX.	Character	-	-	Up to 40 characters
Latitude and ***Longitude***	71 – 72	Y	Denotes the geographical center point of the base study area to be modeled.	Real	Decimal degrees	-	-90 to 90 (Latitude); -180 to 180 (Longitude)
CityRadius	73	N	Defines the radius of the circle enclosing the base study area. Sectors whose centroids do not fall within this radius will not be modeled. Note that if the default value is used, users may want to narrow down the study area further by engaging the ***CountyList*** and/or ***TractList*** parameters (see below) so as to avoid an exceedingly large study area.	Real	km	99999	> 0

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
AirRadius	74	N	The distance provided in this parameter can be thought of as the radius of representativeness of each air quality monitor for which data is provided in the *Air Quality Data* file (i.e., it establishes the size of the air districts). This parameter will override any air radius information provided in the *Air District Locations* file. APEX will assign the air pollutant concentration in a given sector to that measured at the closest air quality monitor, as long as it is within this ***AirRadius*** distance. Any sector whose centroid is not within the ***AirRadius*** of at least one air quality monitor will not be modeled.	Real	km	99999	> 0
ZoneRadius	75	N	As with the ***AirRadius*** parameter, this parameter can be thought of as the radius of representativeness of each meteorological data station for which data is provided in the *Meteorology Data* file (i.e., it establishes the size of the meteorology zones). APEX will assign the metrological data in a given sector to that measured at the closest meteorological data station, as long as it is within the ***ZoneRadius***. Any sector whose centroid is not within the ***ZoneRadius*** of at least one meteorological site will not be modeled.	Real	km	99999	> 0
Altitude	76	N	The altitude of the entire study area (assumed to not vary across the modeling domain). This parameter is necessary when modeling carbon monoxide to determine blood carboxyhemoglobin (COHb) concentrations.	Real	Feet Above Sea Level	0	-
CountyList	77	N	Defines whether (**Y**) or not (**N**) the sectors used in the analysis are limited to a specific list of counties, which is then defined with the parameter ***County*** (see below). See Section 3.2.1.1 for details on how this variable interacts with the ***TractList*** and ***Tract*** variables to define the area being analyzed. If both the ***CountyList*** and ***TractList*** parameters are set to **Y**, the union of the sectors in the list of ***Counties*** and the list of ***Tracts*** results in the final list of potentially modeled sectors.	Character	-	**N**	**Y** (**Yes**) or **N** (**No**)

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
County	78 – 82	N	Only used if ***CountyList*** is set to **Y**. A list of 5-character county codes of the "counties" to be analyzed, and these codes must match the first 5 characters of the sector identifiers in the *Population Sector Location* file. Use multiple instances of ***County*** on consecutive lines if modeling multiple "counties".	Character	-	-	5-character string
TractList	-	N	Defines whether (**Y**) or not (**N**) the sectors used in the analysis are limited to a specific list of sectors, which is then defined with the parameter ***Tract*** (see below). See Section 3.2.1.1 for details regarding how this variable interacts with the ***CountyList*** and ***County*** variables to define the area being analyzed. Users should note that if both the ***CountyList*** and ***TractList*** parameters are set to **Y**, the union of the sectors in the list of ***Counties*** and the list of ***Tracts*** results in the final list of potentially modeled sectors.	Character	-	**N**	**Y** or **N**
Tract	-	N	Only utilized if ***TractList*** is set to **Y**. Parameter containing the 11-character codes of the "tracts" to be analyzed. "Tracts" are identified as the first 11 characters of the sector identifiers in the *Population Sector Location* file. For multiple "tracts", multiple instances of the variable ***Tract*** must be used, and must occupy consecutive lines on the control options file.	String	-	-	11-character string
Time Period Parameters (Basic)							
Start_date and ***End_date***	85 – 86	Y	The start and end dates of the modeling period in the format YYYYMMDD. Note that data for this time period must be present in the *Air Quality Data* and *Meteorology Data* files, and that this time period must be reflected in the time period enumerated in the *Air District Location* and *Meteorology Zone Location* files.	Integer	-	-	-

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
TimeStepsPerDay	87	N	An integer defining the number of time steps per day in the *Air Quality Data* file (e.g., for half-hourly air quality data, ***TimeStepsPerDay*** would equal 48). See Section 3.2.1.4 for further details.	Integer	-	24	See Section 3.2.1.4.
DSTadjust	88	N	Denotes whether (**Y**) or not (**N**) the times provided in the *Air Quality Data* file will be adjusted for Daylight Savings Time. This parameter should be set to **Y** if the times in the *Air Quality Data* file are based on Standard Time (year-round) while the activity diaries data are based on usage of Daylight Savings Time (this is typically the case).	Character	-	**Y**	**Y** or **N**
Microenvironment Parameters (Basic)							
#micros	91	Y	An integer defining the number of microenvironments that are represented in the *Microenvironment Mapping* and *Microenvironment Descriptions* files.	Integer	-	-	Must be the same as on the two microenvironment input files
Commuting Parameters (Basic)							
Commuting	94	N	A binary parameter defining whether (**Y**) or not (**N**) a modeled individual will commute to work (this work sector will be randomly assigned based on the commuting data). If ***Commuting*** is set to **Y**, the *Commuting Flow* and *Commuting Time* files must be provided.	Character	-	**N**	**Y** or **N**
KeepLeavers	95	N	A binary parameter defining whether (**Y**) or not (**N**) data from profiles that work outside of the study area are written to the output tables.	Character	-	**N**	**Y** or **N**

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
LeaverMult and ***LeaverAdd***	96 – 97	N	Only used if ***KeepLeavers*** is set to **Y**; define adjustments needed to estimate air concentrations outside of the modeling domain for individuals working there. $Outside_{Conc} = (\boldsymbol{LeaverMult} \times Avg_{Conc}) + \boldsymbol{LeaverAdd}$ Where $Outside_{Conc}$ is the pollutant concentration at work outside of the modeling domain and Avg_{Conc} is the domain-wide average pollutant concentration. If ***KeepLeavers*** is set to **Y**, users should keep in mind the default value of **LeaverMult** (0) and the impact this would have on pollutant concentration outside of the modeling domain. See Section 4.2.3 of UG1 for details.	Real	-	0	LeaverMult: ≥ 0 LeaverAdd: ≥ 0
Diary Selection Parameters (Basic)							
AgeMin and ***AgeMax***	100 – 101	Y	Define the minimum and maximum age (respectively) of the population being modeled. The randomly-assigned age of the profile is used to determine the individual diaries and physiological parameters. Note that any profiles assigned an age above 99 will be assumed to be 99 years old. Also note that these age bounds are static, so that for APEX runs lasting a year or longer, the minimum and maximum ages stay constant.	Integer	Years	-	0 to 99
ChildMin and ***ChildMax***	102 – 103	N	Define the minimum and maximum ages (respectively) of modeled individuals that will be included in the "child" and "active child" subgroups in the output exposure tables.	Integer	Years	0 (for both)	0 to 99

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
Miscellaneous Parameters (Basic)							
RandomSeed	106	N	APEX uses random number generation as part of its random sampling of various input data. A value of 0 for this parameter will let APEX generate its own initial random number (using the computer's clock). A value between 1 and 2147483646 will force APEX to start the pseudorandom number generation with the specified number. Conducting the same APEX run twice with the same value of ***RandomSeed*** will result in identical outputs between the runs (see Section 4.2.3 of UG1).	Integer	-	0	0 to 2147483646
Disease	107	N	A character variable defining the condition or disease that will be attributed to a sub-group of the modeled population. If this variable is set, the *Prevalence* file must be defined as well. See Section 3.2.1.7 for further details.	Character	-	-	1- to 12-character string
Pollutant Parameters (Basic)							
#Pollutants	110	N	Defines the number of pollutants to be modeled in the run.	Integer	-	1	> 0
pollutant	111	Y	The name of the pollutant to be modeled. Each pollutant name must be followed by its pollutant-specific job parameters (for particulate matter pollutants, "PM" must be at the beginning of the pollutant name).	Character	-	-	1- to 40-character string
InputUnits	112	N	The units for the air quality data. Note that "ppm" denotes parts per million, "ppb" denotes parts per billion, and "UGM3" denotes micrograms per cubic meter.	Character	-	ppm	ppm, ppb, or UGM3
OutputUnits	113	N	The units for the output exposure concentrations.	Character	-	ppm	ppm, ppb, or UGM3

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
Study Area Parameters (Advanced)							
ModelAQVar	151	N	A binary parameter defining whether the air quality values in the *Air Quality Data* file are single values (**N**) or distributions of values (**Y**) per location and timestep.	Character	-	**N**	**Y** or **N**
NearbyRadius	152	N	Defines the radial extent around the home or work sector for randomly selecting the sector where certain diary activities will take place (i.e., those activities taking place in a location denoted as "other" as might be the case for generic activities like shopping or going to a restaurant).	Real	km	20	> 0
ResampleN	153	N	A binary parameter defining whether a nearby sector is randomly chosen where certain diary activities will take place for each day (**Y**) or if the same nearby sector is used for the entire simulation (**N**).	Character	-	**N**	**Y** or **N**
Diary Selection Parameters (Advanced)							
ComCut1, ***ComCut2***, ***ComProbab1***, and ***ComProbab2***	156 – 159	N	Used to define how the activity diaries are matched to profiles based on commuting time. APEX generates a commuting time (t_{comm}) for each profile (if ***Commuting*** = **Y**). APEX must then identify a diary day with an appropriate commuting time. If ***ComCut1*** is provided (in minutes), APEX will assign a probability of 1 to diary days with commuting times that are $t_{comm} \pm \boldsymbol{ComCut1}$. If ***ComCut2*** (in minutes) and ***ComProbab1*** (a decimal value 0–1) are provided, then APEX will assign a sample weighting of ***ComProbab1*** to diary days with commuting times that are $t_{comm} \pm \boldsymbol{ComCut2}$ and outside of the window described by ***ComCut1***. If ***ComProbab2*** (a decimal value 0–1) is provided, then APEX will assign a sample weighting of ***ComProbab2*** to diary days with commuting times that are outside of $t_{comm} \pm \boldsymbol{ComCut2}$**.** All four parameters should not be set to zero in the same run (see Section 4.2.3 of UG1).	See Section 4.2.3 of UG1 for details.	See Section 4.2.3 of UG1 for details.	See Section 4.2.3 of UG1 for details.	See Section 4.2.3 of UG1 for details.

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
MissGender[4], ***MissEmpl***, and ***MissAge***	160 – 162	N	Parameters used to adjust the probability of selecting diaries with missing sex, employment, and age identifiers. A value of 1 means all diaries are equally likely to be chosen regardless of these missing identifiers; a value of 0 means that diaries with missing identifiers will never be chosen.	Real	-	0	0 to 1
AgeCutPct and ***Age2Probab***	163 – 164	N	Parameters used to define how activity diaries are matched to profiles by age. APEX generates an age for each profile (Age_{Prof}) and must then identify a diary day with an appropriate age using age windows. With ***AgeCutPct***, APEX will assign a probability of 1 to diary days with ages that are within that percentage of Age_{Prof}. If ***Age2Probab*** is also provided, then APEX will assign a sample weighting of ***Age2Probab*** to diary days with ages that are outside of the age window defined by ***AgeCutPct*** but still within an age window defined by twice the value of ***AgeCutPct*** (i.e., an age window twice as large as that of ***AgeCutPct)*** (see Table 4-4 of UG1).	Real	**AgeCutPct**: % **Age2Probab**: numeric	0 (for both)	**AgeCutPct**: 0 to 100 **Age2Probab**: 0 to 1
Miscellaneous Parameters (Advanced)							
COHBFact	167	N	A convergence parameter used in solving the equation that calculates carboxyhemoglobin (COHb) for carbon monoxide exposure. The larger this factor, the higher the accuracy of the solution but the slower the modeling time. Values between 2 and 3 are typically suitable. This value is required only if carbon monoxide is being modeled and the dose is being calculated.	Real	-	-	≥ 2
SampleOtherLocs	168	N	A binary indicator defining whether (**Y**) or not (**N**) a random list of air districts will be selected for each profile to assign an air district (and thus pollutant concentration) to that profile's diary activities taking place in a location denoted as "other".	Character	-	**N**	**Y** or **N**

[4] Note that the APEX model (i.e., source code, inputs, and outputs) might use "gender" rather than "sex" but they are intended to be synonymous. Future versions of APEX might replace "gender" with "sex."

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
#OtherDistricts	169	N	Only used if ***SampleOtherLocs*** is **Y**; defines the number of air districts that will comprise the random list from which the air district where the profile's "other" activities take place will be assigned.	Integer	-	1	> 0
HomeProbab	170	N	Only used if ***SampleOtherLocs*** is **Y**; defines the probability that the profile's home district will be in the random list of air districts that could be assigned as the location of the "other" activities.	Real	-	0	0 to 1
OccFactor	171	N	A binary parameter that indicates whether (**Y**) or not (**N**) the *Profile Factors* file contains an occupation parameter. If **Y**, the profile factor is applied to employed profiles only, and an extra factor group is made for unemployed profiles (see Table 4-4 and Section 4.12 of UG1 for more details).	Character	-	**N**	**Y** or **N**
Pollutant Parameters (Advanced)							
PPMFactor	114	N	The number of micrograms per cubic meter that equals the parts per million of the pollutant. This parameter is the same regardless of the ***InputUnits*** or ***OutputUnits.*** This parameter is only required if either the ***InputUnits*** or ***OutputUnits*** (but not both) are in micrograms per cubic meter, or if any microenvironments contain emission source terms and the ***InputUnits*** are not already in micrograms per cubic meter.	Real	-	-	> 0
AlertThresh	115	N	A real number defining an exposure concentration above which exposures are considered. The number of exceedances and the time an individual spends over this threshold are reported for each profile that exceeds the threshold.	Real	Same as ***OutputUnits***	0	≥ 0
DoDose	116	N	A binary parameter indicator whether (**Y**) or not (**N**) dose calculations will be performed.	Character	-	**N**	**Y** or **N**

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
#sources	117	N	An integer defining the largest number of sources in a single microenvironment.	Integer	-	0	≥ 0
Roadway	118	N	A binary parameter indicator whether (**Y**) or not (**N**) roadway concentrations will be used when a modeled individual is in a roadway microenvironment.	Character	-	**N**	**Y** or **N**
Percentiles	119	Y	Comma-separated list of real numbers enumerating the percentiles of the population to be analyzed in the exposure and dose tables in the *Output Tables* file.	Comma-separated list of real numbers	-	-	> 0 and <100
TimeExp	120	N	Comma-separated list of real numbers specifying the exposure cut-points for summing time spent at various exposure levels for two of the tables in the *Output Tables* file (exposure table types 1 and 2; see Section 5.8 of UG1).	Comma-separated list of real numbers	Minutes	-	> 0
DM1HExp[5]	121	N	Comma-separated list of real numbers specifying the daily maximum 1-hour exposure cut-points for binning the person-days in the simulation period. If the timestep of the analysis is longer than an hour (i.e., ***TimeStepsPerDay*** is less than 24) then 1-hour tables are not generated.	Comma-separated list of real numbers	Same as ***OutputUnits***	-	> 0
DM8HExp[5]	122	N	Comma-separated list of real numbers specifying the daily maximum 8-hour exposure cut-points for binning the person-days in the simulation period. If the timestep of the analysis is longer than an hour (i.e., ***TimeStepsPerDay*** is less than 24) then 8-hour tables are not generated.	Comma-separated list of real numbers	Same as ***OutputUnits***	-	> 0

[5] There are analogous parameters for dose; see Section 4.2.2 in UG1.

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
DMTSExp[5]	123	N	Comma-separated list of real numbers specifying the daily maximum timestep exposure cut-points for binning all the person-days in the simulation period. It is similar to ***DM1HExp*** except 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).	Comma-separated list of real numbers	Same as ***OutputUnits***	-	> 0
DAvgExp[5]	124	N	Comma-separated list of real numbers specifying the cut-points for daily average exposure for binning the person-days in the simulation period.	Comma-separated list of real numbers	Same as ***OutputUnits***	-	> 0
SAvgExp[5]	125	N	Comma-separated list of real numbers specifying cut-points for average exposure over the simulation period. The cut-points are used to bin all simulated persons (profiles) created in a run.	Comma-separated list of real numbers	Same as ***OutputUnits***	-	> 0
ResponseVar	126	N	Exposure table from which to use the exposure levels to calculate the number of persons expected to have a positive response (based on the ***ResponseProb*** probabilities) for each exposure bin (see UG1 Section 4.2.2).	Character	-	-	DMH1, DM8H, or DMTS
ResponseProb	127 – 136	N	List of probabilities that define an exposure-response function (see UG1 Section 4.2.2).	Comma-separated list of real numbers	-	-	0 to 1
TSMulti	139	N	Comma-separated list of real numbers specifying the number of exceedances to use as cut-points in exposure table type 9 and dose table type 5 (see Section 5.8 of UG1).	Comma-separated list of real numbers	-	-	> 0
TSExp	140	N	Comma-separated list of real numbers specifying timestep exposure cut-points for counting multiple exceedances of timestep levels over the simulation for exposure table type 9 (see Section 5.8 of UG1).	Comma-separated list of real numbers	Same as ***OutputUnits***	-	> 0

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
HourlyFEVE1	143	N	Binary indicator establishing whether the constant intra-individual variability term used by the %ΔFEV1 model will be sampled hourly (**Y**), or whether it will be sampled daily (**N**).	Character	-	**N**	**Y** or **N**
HourlyFEVE2	144	N	Binary indicator establishing whether the ozone-dependent intra-individual variability term used by the %ΔFEV1 model will be sampled hourly (**Y**) or whether it will be sampled daily (**N**).	Character	-	**N**	**Y** or **N**
Rollback Parameters (Advanced)							
Rollback	174	N	Binary indicator establishing whether (**Y**) or not (**N**) adjustments will be made to the air quality data prior to exposure calculations to explore hypothetical exposure scenarios.	Character	-	**N**	**Y** or **N**
RBtarget	175	N	Only used if ***Rollback*** is set to **Y**; establishes the target rollback pollutant concentration. This value should be less than the ***RBmax*** (see below).	Real	Same as ***InputUnits***	0	≥ 0
RBmax	176	N	Only used if ***Rollback*** is set to **Y**; defines the rollback maximum concentration.	Real	Same as ***InputUnits***	0	≥ 0
RBbackgnd	177	N	Only used if ***Rollback*** is set to **Y**; define the rollback background concentration, i.e., the portion of the air quality data that is unaffected by the rollback scenario.	Real	Same as ***InputUnits***	0	≥ 0
Diagnostic Parameters (Advanced)							
DebugLevel	180	N	An integer between 0 and 3 indicating the relative amount of information to be written to the *Log* file. A value of 0 will produce the smallest amount of output to the *Log* file (this is the preferred value to use when running APEX with a large number of profiles). Users trying to understand problems arising during the execution of APEX should set this parameter to between 1 and 3.	Integer	-	0	0, 1, 2, or 3

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
Log File Switches (Advanced)							
LogDistrict	183	N	A binary indicator defining whether or not a list of the names and locations of all the preliminary and final air districts is written to the *Log* file.	Character	-	**Y**	**Y** or **N**
LogPopulation	184	N	A binary indicator defining whether or not initial and final population statistics for the study area are written to the *Log* file.	Character	-	**Y**	**Y** or **N**
LogProfiles	185	N	A binary indicator defining whether or not sector-specific population statistics are written to the *Log* file.	Character	-	**Y**	**Y** or **N**
LogSectors	186	N	A binary indicator defining whether or not a list of the names and locations of all the preliminary and final sectors are written to the *Log* file.	Character	-	**N**	**Y** or **N**
LogTables	187	N	A binary indicator defining whether or not all tables written to the *Tables* output file are also included in the *Log* file.	Character	-	**N**	**Y** or **N**
LogZones	188	N	A binary indicator defining whether or not the preliminary and final list of the names and locations of the meteorology zones are written to the *Log* file.	Character	-	**Y**	**Y** or **N**
Sobol Analysis Parameters (Advanced)							
SobolRun	191	N	A binary indicator defining whether (**Y**) or not (**N**) a Sobol sensitivity analysis will be run in APEX using the values in the *Seed Offsets and Sobol Grouping* file. No other output files will be created.	Character	-	**N**	**Y** or **N**
SobolVarList	192	N	A Comma- or space-separated list of strings defining the APEX output variables that will be subjected to the Sobol sensitivity analysis. See Section 11 of UG2 for details regarding Sobol sensitivity analysis in APEX.	Comma- or space-separated list of strings	-	-	-

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
Longitudinal and Clustering Diary Parameters (Advanced)							
LongitDiary, DiaryAutoC, DiaryD, ClusterDiary, ClusterAges, and ***UseAdjacent***	195 – 202	See Section 6.3 of UG2	Parameters used to define the method in which the longitudinal diary assembly occurs. Users are referred to Section 6.3 of UG2 for a detailed explanation of this methodology.	See Section 6.3 of UG2	See Section 6.3 of UG2	See Section 6.3 of UG2	See Section 6.3 of UG2
Output Tables File Parameters							
HeavyEVR1	205	N	Sets the threshold for equivalent ventilation rate defining one-hour heavy exertion. This is used in the output tables for one-hour exposure under heavy exertion.	Real	Liter/minute-m^2	0	≥ 0
HeavyEVR8	206	N	Sets the threshold for equivalent ventilation rate defining eight-hour heavy exertion. This is used in the output tables for eight-hour exposure under heavy exertion.	Real	Liter/minute-m^2	0	≥ 0
ModEVR1	207	N	Sets the threshold for equivalent ventilation rate defining one-hour moderate exertion. This is used in the output tables for one-hour exposure under moderate exertion.	Real	Liter/minute-m^2	0	≥ 0
ModEVR8	208	N	Sets the threshold for equivalent ventilation rate defining eight-hour moderate exertion. This is used in the output tables for eight-hour exposure under moderate exertion.	Real	Liter/minute-m^2	0	≥ 0
ActivePAI	209	N	Threshold median daily PAI (MET) value for defining active persons. In the output exposure tables, those profiles having simulation-median PAI greater than or equal to ***ActivePAI*** are included in the 'active persons' subgroup.	Real	-	0	≥ 0

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
ModEVRTS	210	N	Sets the threshold for equivalent ventilation rate defining timestep-level moderate exertion. Used in generating output tables for timestep exposures under moderate exertion.	Real	Liter/minute-m^2	0	≥ 0
HeavyEVRTS	211	N	Sets the threshold for equivalent ventilation rate defining timestep-level heavy exertion. Used in generating output tables for timestep exposures under heavy exertion.	Real	Liter/minute-m^2	0	≥ 0
Output File Settings							
TablesList	218	N	List of keywords specifying the tables to be written to the *Output Tables* file. See Sections 4.5 and 4.6 for further details and a list of keywords for output tables available to be written to this file.	Comma- or space-separated list of strings	-	-	-
PSumList	222	N	List of keywords specifying the variables to be written to the *Profile Summary* file. See Table 4-2 for a list of keywords for variables available to be written to this file.	Comma- or space-separated list of strings	-	See Table 4-2	-
TimeStepOut	225	N	A binary indicator for whether (**Y**) or not (**N**) the *Timestep* file will be generated. The *Timestep* file will only be generated if the timestep is not hourly (an hourly *Timestep* file would be roughly identical to the *Hourly* file; see ***HourlyOut*** and ***HourlyList*** below).	Character	-	**N**	**Y** or **N**
TimeStepList	226	N	Only used if ***TimeStepOut*** is set to **Y**; this parameter is a list of the variables to be included in the *Timestep* file. See Section 5.3 of UG1 for a list of default and optional keywords for variables available to be written to this output file.	Comma- or space-separated list of strings	-	See Section 5.3 of UG1	See Section 5.3 of UG1
MSumOut	229	N	A binary indicator for whether (**Y**) or not (**N**) the *Microenvironmental Summary* file will be generated. See Section 5.7 of UG1 for details regarding this optional output file.	Character	-	**N**	**Y** or **N**

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
MResOut	232	N	A binary indicator for whether (**Y**) or not (**N**) the *Microenvironmental Results* file will be generated. Users should note that this output file can be exceedingly large and writing this file can greatly increase the model runtime.	Character	-	**N**	**Y** or **N**
MResHome	233	N	A binary indicator for whether (**Y**) or not (**N**) the *Microenvironmental Results* file will only contain values associated with the "home" microenvironment. If N, then this file also contains values for the other microenvironments.	Character	-	**N**	**Y** or **N**
MResMicros	234	N	Only used if ***MResOut*** is set to **Y**; this parameter defines the list of microenvironments for which data will be written in the *Microenvironmental Results* file (see below). If this parameter is used, all of the microenvironments enumerated must be present. For example, if ***#micros*** = 5, the only possible values in ***MResMicros*** can be 1, 2, 3, 4, and/or 5. Including other numbers of microenvironments will cause APEX to throw an error.	Comma-separated list of integers	-	-	Limited by the number of microenvironments modeled.
MResList	235	N	Only used if ***MResOut*** is set to **Y**; this parameter is a list of the variables to be included in the *Microenvironmental Results* file. See Table 4-3 for a list of keywords for variables available to be written to this output file.	Comma- or space-separated list of strings	-	See Table 4-3	See Table 4-3
EventsOut	239	N	A binary indicator for whether (**Y**) or not (**N**) the *Events* file will be generated.	Character	-	**N**	**Y** or **N**
EventSample	240	N	Only used if ***EventsOut*** is set to **Y**; parameter defining the number of profiles to be written to the *Events* file. This number of profiles is chosen from the total number of profiles via evenly spaced intervals (e.g., if ***EventsList*** = **Y**, ***#profiles*** = 1000, and ***EventSample*** = 10, then the 100th, 200th, 300th, etc. profiles will be written to the *Events* file).	Integer	-	10	> 0; Cannot exceed ***#profiles***

Parameter Name	Line in Example Run *COF*	Required?	Description	Format[a]	Units	Default Value	Possible Values
CustomSample	241	N	Only used if ***EventsOut*** is **Y**; a list of integers defining the profiles for which information will be written to the *Events* file. The union of profiles from ***EventSample*** and ***CustomSample*** will be used as the final list of such profiles.	Comma-separated list of integers	-	-	> 0
EventsList	242	N	Only used if ***EventsOut*** is **Y**; a list of the variables to be included in the *Events* file. See Section 5.10 of UG1 for a list of the default and optional keywords for available variables.	Comma- or space-separated list of strings	-	See Section 5.10 of UG1	See Section 5.10 of UG1
HourlyOut	245	N	A binary indicator for whether (**Y**) or not (**N**) the *Hourly* file will be generated. Users should note that if the ***TimeStepsPerDay*** parameter is set to less than 24 (i.e., the time step of air quality data is coarser than hourly) the *Hourly* file will not be written. In this case, users should output the *Timestep* file using the ***TimeStepOut*** and ***TimeStepList*** parameters (see above).	Character	-	**N**	**Y** or **N**
HourlyList	246	N	Only used if ***HourlyOut*** is set to **Y**; this parameter is a list of the variables to be included in the *Hourly* file. See Section 5.2 of UG1 for a list of the default and optional keywords for variables available to be written to the *Hourly* file.	Comma- or space-separated list of strings	-	See Section 5.2 of UG1	See Section 5.2 of UG1
DailyOut	250	N	A binary indicator for whether (**Y**) or not (**N**) the *Daily* file will be generated.	Character	-	**N**	**Y** or **N**
DailyList	251	N	Only used if ***DailyOut*** is set to **Y**; this parameter is a list of the variables to be included in the *Daily* file. See Section 5.4 of UG1 for a list of the default and optional keywords for variables available to be written to the *Daily* file.	Comma- or space-separated list of strings	-	See Section 5.4 of UG1	See Section 5.4 of UG1

[a]Parameter values are defined as one of four different data types: “Real” meaning a real number (or, simply put, a number that can also have values in the decimal places), “Integer” meaning any whole number zero or greater, and “Character” or “String” meaning text (often limited to specific characters and a specific length).

```
!!! END OF INPUT/OUTPUT FILE PATHS !!!

!!! START OF BASIC PARAMETER SETTINGS !!!

! STUDY AREA PARAMETERS
#profiles   = 100
Location    = Los Angeles Area
Latitude    = 34.10374
Longitude   = -117.62914
CityRadius  = 999.      ! Input as km
AirRadius   = 30.       ! Input as km
ZoneRadius  = 999.      ! Input as km
Altitude    = 200       ! Input as feet
CountyList  = YES
 County = 06037
 County = 06059
 County = 06065
 County = 06071
 County = 06111

! TIME PERIOD PARAMETERS
Start_date  = 20100601  ! Input as YYYMMDD
End_date    = 20100831  ! Input as YYYMMDD
TimeStepsPerDay = 24
DSTadjust   = YES

! MICROENVIRONMENT PARAMETERS
#micros     = 5

! COMMUTING PARAMETERS
Commuting   = YES       ! Must include employment, commuting, and commtime files if YES.
KeepLeavers = YES
LeaverMult  = 1.0
LeaverAdd   = 0.0
```

Figure 3-5. Screenshot of the Example APEX *COF* Showing Basic Input Parameter Settings for the Study Area, Time Period, Microenvironment, and Commuting Parameters.

```
! DIARY SELECTION PARAMETERS
AgeMin      =  5
AgeMax      = 99
ChildMin    =  5
ChildMax    = 18

! MISCELLANEOUS PARAMETERS
RandomSeed  = 4178348
Disease     = Asthma    ! Must include Prevalence file if set.

! POLLUTANT PARAMETERS
#Pollutants  = 1
pollutant    = Ozone
InputUnits   = ppm
OutputUnits  = ppm
PPMFactor    = 1.
AlertThresh  = 0.3
DoDose       = NO
#sources     = 0
Roadway      = NO
Percentiles  = 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 99
TimeExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16
DM1HExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16
DM8HExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16
DMTSExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16
DAvgExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16
SAvgExp      = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16
ResponseVar  = DM1H
ResponseProb = FEV1>10,  2.5 pctl : 0 ,0 ,0 ,0 ,0.015555 ,0.03962 ,0.09126 ,0.1708 ,0.2526 ,0.31025 ,0.3588 ,
ResponseProb = FEV1>10, 50.0 pctl : 0.0003399 ,0.001646 ,0.0046625 ,0.0117 ,0.02893 ,0.06169 ,0.1206 ,0.2055
ResponseProb = FEV1>10, 97.5 pctl : 0.0008508 ,0.00376 ,0.0096825 ,0.021725 ,0.05804 ,0.1128 ,0.16955 ,0.2428
ResponseProb = FEV1>15,  2.5 pctl : 0 ,0 ,0 ,0 ,0 ,0 ,0.02794 ,0.07008 ,0.12775 ,0.17735 ,0.2141 ,0.228 ,0.23
ResponseProb = FEV1>15, 50.0 pctl : 0.000062955 ,0.00032745 ,0.001015 ,0.002786 ,0.0073 ,0.018635 ,0.04578 ,0
ResponseProb = FEV1>15, 97.5 pctl : 0.0002348 ,0.001082 ,0.00288 ,0.006766 ,0.014985 ,0.032005 ,0.06694 ,0.12
ResponseProb = FEV1>20,  2.5 pctl : 0 ,0 ,0 ,0 ,0 ,0 ,0.005029 ,0.02303 ,0.06462 ,0.09985 ,0.12645 ,0.1425 ,0
ResponseProb = FEV1>20, 50.0 pctl : 1.411E-6 ,9.925E-6 ,0.00004369 ,0.0001773 ,0.0007059 ,0.002848 ,0.01204 ,
ResponseProb = FEV1>20, 97.5 pctl : 0.00002287 ,0.0001221 ,0.00038465 ,0.001083 ,0.00301 ,0.0084935 ,0.02788
ResponseProb = Bin counts         : 1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1
```

Note: Text on the right has been cut off in this screenshot.

Figure 3-6. Screenshot of the Example APEX *COF* Showing Basic Input Parameter Settings for Diary Selection, Miscellaneous, and Pollutant Parameters.

```
! OUTPUT TABLE LEVELS: PARAMETERS FOR TIMESTEPS NE 1 HOUR
TSMulti      = 1, 2, 3, 5, 10, 20
TSExp        = 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13,

! Minute dFEV1 model parameters
HourlyFEVE1  = NO
HourlyFEVE2  = NO

!!! END OF BASIC PARAMETER SETTINGS !!!

!!! START OF ADVANCED PARAMETER SETTINGS !!!

! STUDY AREA PARAMETERS
ModelAQVar   = NO
NearbyRadius = 10
ResampleN    = NO

! DIARY SELECTION PARAMETERS
ComCut1     = 50.0
ComCut2     = 100.0
ComProbab1  = 0.20
ComProbab2  = 0.05
MissGender  =  0.0
MissEmpl    =  0.0
MissAge     =  0.0
AgeCutPct   = 15.0
Age2Probab  =  0.05

! MISCELLANEOUS PARAMETERS
COHbFact        = 2.5
SampleOtherLocs = NO
#OtherDistricts = 2
HomeProbab      = 0
OccFactor       = NO
```

Note: Text on the right has been cut off in this screenshot.

Figure 3-7. Screenshot of the Example APEX *COF* Showing Basic Input Parameters for Pollutant Parameters (continued) and Advanced Study Area, Diary Selection and Miscellaneous Parameters.

```
173  ! ROLLBACK PARAMETERS
174  Rollback    = NO
175  RBtarget    =  5.0
176  RBmax       = 10.0
177  RBbackgnd   =  0.0
178
179  ! DIAGNOSTICS PARAMETERS
180  DebugLevel  = 0
181
182  ! LOG FILE SWITCHES
183  LogDistrict   = NO
184  LogPopulation = NO
185  LogProfiles   = NO
186  LogSectors    = NO
187  LogTables     = NO
188  LogZones      = NO
189
190  ! SOBOL ANALYSIS PARAMETERS
191  SobolRun      = NO
192  !SobolVarList = AVGEXP MAX1EXP MAX8EXp MAXTSEXP MAX8EC AVGDOSE MAX1DOSE MAX8DOSE M
193
194  ! LONGITUDINAL DIARY PARAMETERS
195  LongitDiary  = YES
196  DiaryAutoC   = 0.2
197  DiaryD       = 0.5
198
199  ! CLUSTERING DIARY PARAMETERS
200  ClustDiaryA  = NO
201  RERUNCLUS    = NO
202  ClustDiaryB  = NO
203
```

Note: Text on the right has been cut off in this screenshot.

Figure 3-8. Screenshot of the Example APEX *COF* Showing Advanced Input Parameters for Rollback, Diagnostic, *Log* File, Sobol Analysis, Longitudinal Diary, and Clustering Diary Parameters.

```
204  ! OUTPUT TABLES FILE PARAMETERS
205  HeavyEVR1     = 99
206  HeavyEVR8     = 99
207  ModEVR1       = 16
208  ModEVR8       = 13
209  ActivePAI     = 1.76
210  ModEVRTS      = 99
211  HeavyEVRTS    = 99
212
213  !!! END OF ADVANCED PARAMETER SETTINGS !!!
214
215  !!! START OF OUTPUT FILE SETTINGS !!!
216
217  ! OUTPUT TABLES FILE
218  TablesList      = EXP1H MICROTIME
219  !TablesList     = EXP1H EXP8H EXPTS EXPAVG DOSE1H DOSE8H DOSE1EH DOSETS DOSEAVG MICE
220
221  ! PROFILE SUMMARY FILE
222  !PSumList       = #DIARIES FGROUP GROUPNAME ROADDIST RWDIST COMMDIST COMMTIME ACCAR
223
224  ! TIMESTEP FILE
225  TimeStepOut     = YES
226  !TimeStepList   = VE VA EVR MET EE AMB EXP DOSE INTAKEDOSE DEPDOSE EF
227
228  ! MICROENVIRONMENTAL SUMMARY FILE
229  MSumOut         = YES
230
```

Note: Text on the right has been cut off in this screenshot.

Figure 3-9. Screenshot of the Example APEX *COF* Showing Advanced Input Parameters for the *Output Tables* File, and File Formatting Parameters for the *Output Tables*, *Profile Summary*, *Timestep*, and *Microenvironmental Summary* Files.

```
231  ! MICROENVIRONMENTAL RESULTS FILE
232  MResOut     = YES
233  MResHome    = YES
234  MResMicros = 1,2,3,4,5
235  MResList    = DAY MONTH DISTRICT DAYWEEK AMB CONC PRX PEN AER RR
236  !MResList   = PRX PEN CSUM AMB CONC ESUM SOURCE VOL AER RR WINDOWRES WINDOWCAR MAXTEMPCAT AVG
237
238  ! EVENTS FILE
239  EventsOut     = YES
240  EventSample   = 10
241  CustomSample = 5,15,20,25
242  !EventsList   = MET UMET VA VE EVR DFEV1 FEVX DEFICIT AMB HOMEAMB FEVE1 FEVE2
243
244  ! HOURLY FILE
245  HourlyOut    = YES
246  HourlyList   = MET EXP1 EXP2 EXP3 EXP4 EXP5 AMB
247  !HourlyList = VE VA EVR MET EE FEVE1 FEVE2 DFEV1 TIME1 TIME2 TIME3 TIME4 TIME5 EXP1 EXP2 EXP
248
249  ! DAILY FILE
250  DailyOut    = YES
251  DailyList   = CHADAGE DFEV1 AVGEXP MAX1EXP
252  !DailyList = CHADID CHADAGE CHADEMP CHADOCC DIARYPOOL PAI KEYVAR WINDOWRES WINDOWCAR SPEEDCA
253
254  !!! END OF OUTPUT FILE SETTINGS !!!
```

Note: Text on the right has been cut off in this screenshot.

Figure 3-10. Screenshot of the Example APEX *COF* Showing File Formatting Parameters for the *Microenvironmental Results*, *Events*, *Hourly*, and *Daily* Files.

3.3. Conducting an Example Run of APEX

In this section, readers are guided through how to set up and run the example APEX model run, the files for which can be found in the Example_run and NationalDefaultDatabases folders installed using the APEX installer from the APEX website.[6]

The overall run specifications are listed below. See Section 3.2.1 for a discussion on how these modeling parameters are defined in the *COF*.

- Pollutant: Ozone
- Profiles: 100 individuals ages 5 years and older
- Location: Five counties in the area of Los Angeles, CA
- Sectors: Census tracts
- Air districts: 53 provided (51 used)
- Time period: June through August, 2010
- Time step: Hourly
- Microenvironments: Five
- Commuting: Yes
- Disease: Yes (asthma)
- Risk calculation: Yes (ResponseProb)

Figure 3-11 demonstrates the steps involved in setting up and running an APEX model run. We provide additional discussion on Step 1 ("Set up the control file") and Step 2 ("Execute the run") in Sections 3.3.1 and 3.3.2, respectively. We discuss Step 3 ("Review the output tables") in Section 4.

[6] APEX website: https://www.epa.gov/fera/human-exposure-modeling-air-pollutants-exposure-model.

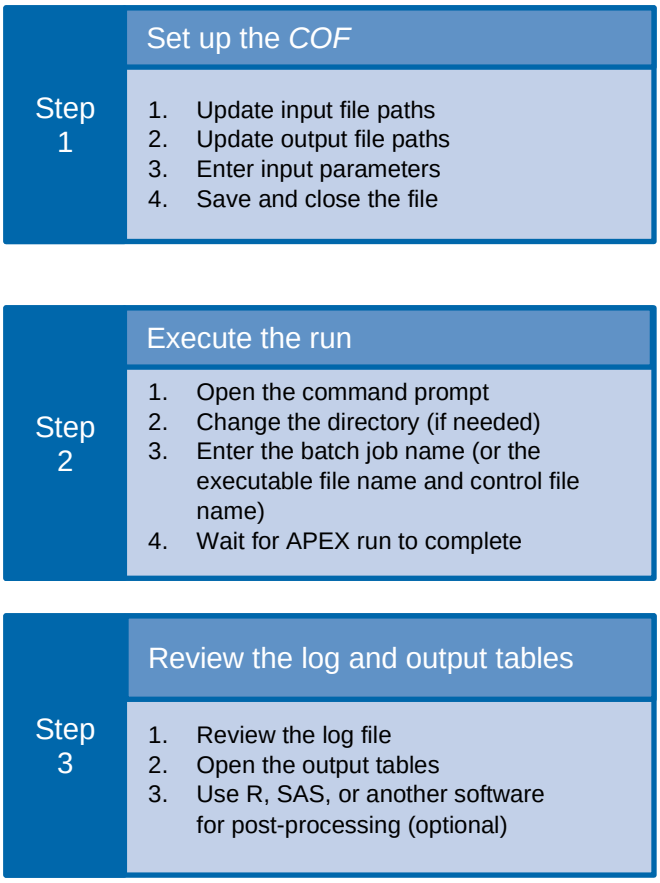


Figure 3-11. Steps for Running APEX

3.3.1. Setting up the Control File

This section explains the basic syntax of the *COF* and the sections of the *COF* that need to be modified by the user before execution of the example run. After installing APEX (see Section 3.1), the *COF* for the example APEX run (named "cof_example.txt") can be found in the Example_run folder. As in Section 3.2.2, figures are provided showing sections of the example run *COF* with line numbers to guide the reader through the setup of the file. The first parts of the example *COF* are discussed in this section, which are related to setting the run description as well as the file paths and file names of the input and output files for the run. The remaining parts of the *COF* (the parameter and output settings) are presented and discussed in Section 3.2.2. For a more detailed discussion of all of the input files and parameters and how to set up an APEX run, see Sections 2–4 of UG1.

Users should note that while the *COF* is structured in a format that reflects a logical grouping and progression of different file path and parameter definitions, for the most part the order in which items are listed in the *COF* is irrelevant. The exceptions to this are listed below.

- The first line of the file is read in for descriptive labeling purposes, regardless of whether or not it has a leading exclamation mark.

- The ***CountyList*** parameter must be immediately followed by the relevant definitions of the ***County*** parameter.
- The ***TractList*** parameter must be immediately followed by the relevant definitions of the ***Tract*** parameter.
- All pollutant parameters for a specific pollutant must immediately follow the corresponding definition of the pollutant in the ***pollutant*** parameter (see Figure 3-6 and Figure 3-7).

The various input and output files and parameters are defined in the *COF* using keywords. These keywords are to the left of an equals sign in the *COF* (e.g., "Scenario", "Air Quality file, Ozone", or "Districts file" between lines 2 and 10 in Figure 3-12), and the values attributed to these keywords are to the right of the equals signs. Keyword definitions for input files and parameters that are not required for APEX to run may be excluded from the *COF* entirely (see Table 3-1 and Table 3-2 for details on which input files and parameters are required).

APEX is not case sensitive with regards to the information entered on the *COF*. Note also only spaces may be used to separate the parameter or file name from the equal sign, not tabs. See Section 4.2 of UG1 for an in-depth discussion of the *COF*.

3.3.1.1. Scenario Descriptions and Input File Paths

The first section of the *COF* contains information briefly describing the location and other specifications of the APEX model run (lines 1 and 2 of Figure 3-12). This text is for descriptive labeling purposes only, and information included on these lines does not impact the results of APEX. As APEX reads in the information on the *COF*, the entirety of this first line is read in and stored for inclusion in the header information of output files (see Section 4). After this first line, any line starting with an exclamation mark is not read by APEX. This is a convenient way for users to provide documentation inside of the *COF*.

The next section of the *COF* contains the full file paths of the input files for the example model run. These paths must be updated to reflect the directory into which the user installed the APEX input files (lines 9–50 of Figure 3-12 and Figure 3-13). Note that for users who installed APEX to the default location in the APEX installer ("C:\APEX"; see Section 3.1) these file paths should not need to be updated. For users who installed APEX to a different directory, only the file paths need to be changed for the example APEX model run as the file names are already set to the correct names of the files extracted from the APEX installer.

```
! cof_example.txt from APEX Intro Document Section 3.3; Example APEX model run
Scenario = Los Angeles (CSA 348), Jun-Aug 2010 Example case, 2010 pop, RandomSeed 4178348
!
!!! START OF INPUT/OUTPUT FILE PATHS !!!

! INPUT FILES
!
! AIR QUALITY AND METEOROLOGY FILES
Air Quality file, Ozone = C:\APEX\Example_run\Air_quality_data_LA_2010.txt
Districts file          = C:\APEX\Example_run\Air_districts_LA_2010.txt
Meteorology file        = C:\APEX\Example_run\Meteorology_data_LA_2010.txt
Zones file              = C:\APEX\Example_run\Meteorology_zones_LA_2010.txt

! MICROENVIRONMENT FILES
Functions file          = C:\APEX\Example_run\Profile_functions.txt
Microenvironment file   = C:\APEX\Example_run\Microenvironment_descriptions_05_MEs.txt
MEMap file              = C:\APEX\Example_run\Microenvironment_mappings_05_MEs.txt

! HUMAN ACTIVITY AND PHYSIOLOGY FILES
DiaryEvent file         = C:\APEX\NationalDefaultDatabases\CHAD_diaries_events.txt
DiaryQuest file         = C:\APEX\NationalDefaultDatabases\CHAD_diaries_questionnaire.txt
DiaryStat file          = C:\APEX\NationalDefaultDatabases\CHAD_diaries_statistics_outdoor.txt
MET Distribution file   = C:\APEX\NationalDefaultDatabases\MET_distributions.txt
METMap file             = C:\APEX\NationalDefaultDatabases\MET_mapping.txt
Physiology file         = C:\APEX\NationalDefaultDatabases\Physiology.txt
Ventilation file        = C:\APEX\NationalDefaultDatabases\Ventilation.txt
Prevalence file         = C:\APEX\Example_run\Disease_prevalence_data_asthma.txt

! POPULATION INPUT FILES
pop file, Female, Asian = C:\APEX\NationalDefaultDatabases\Population_female_Asian_2010.txt
pop file, Female, Black = C:\APEX\NationalDefaultDatabases\Population_female_Black_2010.txt
```

Note: This figure may not exactly match the current contents of the control file.

Figure 3-12. Screenshot of the Example APEX Control File showing Input File Names

```
! POPULATION INPUT FILES
pop file, Female, Asian = C:\APEX\NationalDefaultDatabases\Population_female_Asian_2010.txt
pop file, Female, Black = C:\APEX\NationalDefaultDatabases\Population_female_Black_2010.txt
pop file, Female, Hisp  = C:\APEX\NationalDefaultDatabases\Population_female_Hispanic_2010.txt
pop file, Female, Natam = C:\APEX\NationalDefaultDatabases\Population_female_Native_American_2010.txt
pop file, Female, Other = C:\APEX\NationalDefaultDatabases\Population_female_Other_2010.txt
pop file, Female, White = C:\APEX\NationalDefaultDatabases\Population_female_White_2010.txt
pop file, Male,   Asian = C:\APEX\NationalDefaultDatabases\Population_male_Asian_2010.txt
pop file, Male,   Black = C:\APEX\NationalDefaultDatabases\Population_male_Black_2010.txt
pop file, Male,   Hisp  = C:\APEX\NationalDefaultDatabases\Population_male_Hispanic_2010.txt
pop file, Male,   NatAm = C:\APEX\NationalDefaultDatabases\Population_male_Native_American_2010.txt
pop file, Male,   Other = C:\APEX\NationalDefaultDatabases\Population_male_Other_2010.txt
pop file, Male,   White = C:\APEX\NationalDefaultDatabases\Population_male_White_2010.txt
sectors file            = C:\APEX\NationalDefaultDatabases\Population_sectors_US_2010.txt

! EMPLOYMENT AND COMMUTING FILES
employment file         = C:\APEX\NationalDefaultDatabases\Employment_US_2010.txt
commuting file          = C:\APEX\NationalDefaultDatabases\Commuting_flow_US_2010.txt
commtime file           = C:\APEX\NationalDefaultDatabases\Commuting_times_US_2010.txt

! SENSITIVITY TESTING VARIABLE GROUPING FILE
Seed file               = C:\APEX\Example_run\Seed.txt

! OUTPUT FILES
log file                = C:\APEX\Output\Log_Out.txt
persons file            = C:\APEX\Output\Personal_Summary_Out.txt
tables file             = C:\APEX\Output\Tables_Out.txt
site file               = C:\APEX\Output\Sites_Out.txt
hourly file             = C:\APEX\Output\Hourly_Out.txt
daily file              = C:\APEX\Output\Daily_Out.txt
events file             = C:\APEX\Output\Events_Out.txt
microsum file           = C:\APEX\Output\Microenvironmental_Summary_Out.txt
microres file           = C:\APEX\Output\Microenvironmental_Results_Out.txt
timestep file           = C:\APEX\Output\Timestep_Out.txt

!!! END OF INPUT/OUTPUT FILE PATHS !!!

!!! START OF BASIC PARAMETER SETTINGS !!!
```

Note: This figure may not exactly match the current contents of the control file.

Figure 3-13. Screenshot of the Example APEX Control File showing Input File Names (continued) and Output File Names

3.3.1.2. Output Files Paths, Additional Modifications, Save, and Close

Users may also need to update the directory paths for the output files (lines 53–62 of Figure 3-13). Users who installed APEX to the default location ("C:\APEX") will not need to update these output file paths. In this example APEX run, all 10 possible output files are set to be written (however only 9 will be written as the ***TimeStepsPerDay*** is set to 24 [line 87 of Figure 3-5], so the *Timestep* file will not be written; see Table 3-2 for further details). The names of these files in the APEX example run *COF*, as well as additional information, are enumerated in Table 3-3.

Users modifying this example run *COF* should note that if an output file is defined with the same name and location as an existing file, the old output files are overwritten without any warning being provided by APEX. Therefore, if the user wishes to conduct a series of model runs, the output files for each run should either be uniquely named or be written to a different directory. This is especially important to keep in mind when conducting batch runs of APEX (see Section 3.3.2 as well as Section 2.1 of UG1).

The parameters in the subsequent sections of the *COF* (see Figure 3-5 through Figure 3-10) can be modified by users to perform an APEX run different from the example APEX run provided in the downloaded APEX files or to modify the output files being generated by APEX. Table 3-2 provides some guidance to users modifying the "Basic" parameters; however it is strongly advised that users modifying any of the "Advanced" parameters consult the relevant sections of UG1 and UG2 before making these changes. Additional information regarding modifications to the output files can be found in Section 4 and the relevant sections of UG1 and UG2.

After you have made the requisite changes to the input and output files paths, save and close the *COF* file.

Table 3-3. List of APEX Output Files

	Output File	Name of File in Example Run	Control File Keyword
1	*Log* File	Log_Out.txt	Log file
2	*Profile Summary* (Persons) File	Personal_Summary_Out.txt	Persons file
3	*Output Tables* File	Tables_Out.txt	Tables file
4	*Sites* File	Sites_Out.txt	Site file
5	*Hourly* File	Hourly_Out.txt	Hourly fie
6	*Daily* File	Daily_Out.txt	Daily file
7	*Events* File	Events_Out.txt	Events file
8	*Microenvironmental Summary* File	Microenvironmental_Summary_Out.txt	Microsum file
9	*Microenvironmental Results* File	Microenvironmental_Results_Out.txt	Microres file
10	*Timestep* File	Timestep_Out.txt[1]	Timestep file
11	*Sobol* File	Not used in the example	Sobol file

[1]Note that when an hourly timestep is utilized in APEX, the *Timestep* file will not be generated. Only the *Hourly* file can be generated which contains much of the same information.

3.3.2. Executing the Run In Windows

It is easiest to run APEX with the APEX model executable file and *COF* in the same directory. In the Executables folder from the APEX installation, there are 2 files: “APEX521_r32.exe” and “APEX521_r64.exe”. These refer to executables for 32-bit and 64-bit computers, respectively. Users with 32-bit computers must use the “APEX521_r32.exe” executable, while users with 64-bit computers may employ either the 32-bit or 64-bit versions (though it is suggested they use the 64-bit version). If you do not know whether your computer is 32-bit or 64-bit, click on the Start menu and navigate to the “Computer” folder. In the window that pops up, right click anywhere in the main window (do not right click any of the links to different drives on your computer) and select “Properties”. In the window that pops up, under “System” and “System type:” there will be text identifying whether you have a 32- or 64-bit operating system. In the APEX Executables folder, copy the executable file that matches your system and paste this file into the Example_run folder which contains the example run *COF*.

Open a command prompt (this can be accessed from the Start menu) and change the directory to that containing the APEX executable and example run *COF* for the simulation (e.g., type “cd [path]” where “[path]” denotes the full directory path to the Example_run folder). You can paste text (e.g., the full directory path to the APEX folder) into the command window by right-clicking inside of the command window and selecting “Paste” from the options that appear.

Instead of navigating in the command prompt to the correct directory, users can use Windows Explorer to navigate to the folder that contains the APEX executable and *COF*. Hold the “Shift” button while right clicking inside of the folder. Click “Open command window here” from the list of options that appears. The command window will open set to the correct directory.

Once a command window is open and set to the directory containing the APEX executable and *COF*, type the executable file name, followed by a space, and then the *COF* file name (as shown in Figure 3-14). Then hit the “Enter” (or “Return”) key to run APEX.

When using Windows 10, the command window is replaced by the PowerShell window. In the instructions above, you would click on “Open PowerShell window here” rather than “Open command window here”. In that window, you must add “.\” before the name of the .exe file; otherwise it is as described above.

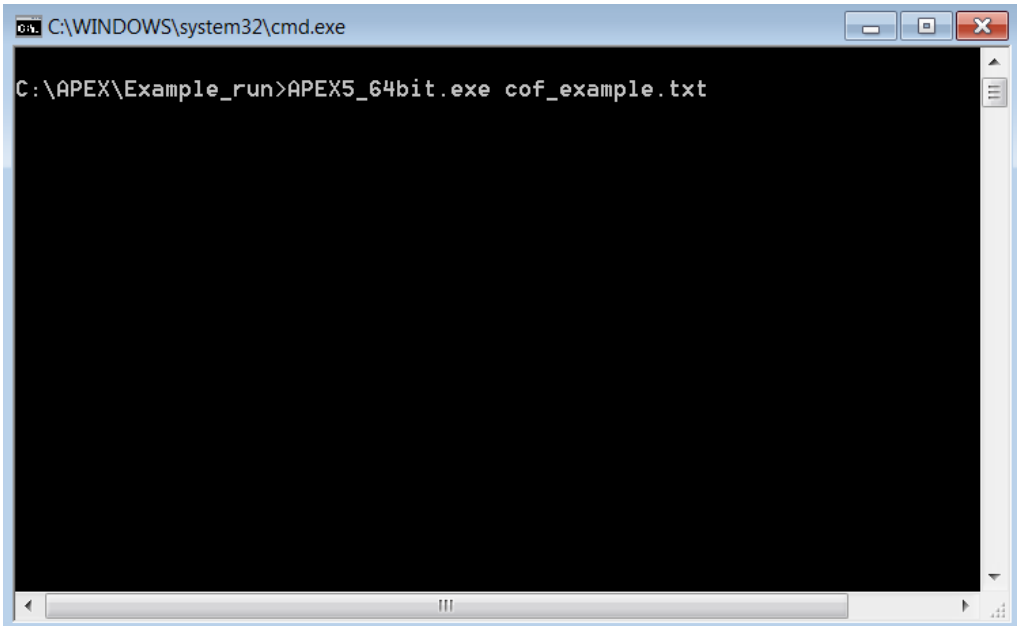


Figure 3-14. Screenshot of Command Prompt with Example APEX Execution Command

After initializing the run, the text written to the command prompt will document the phase of the processing APEX is executing in real time. Initially, the start and end dates of the analysis will be printed, after which several of the input data files will be read in. This may take some time, depending on the processing capabilities of the user's computer and specific file sizes. Then the activity diaries will be read in. After this, "Starting Loop" will appear on the command window, and this phase of processing may take several minutes to complete. Next, the profiles will be sequentially processed, and the user will be updated on the progress of this (note that the number of profiles equals the number entered in line 69 of the *COF*; see Figure 3-5). After the final profile is processed, a completion statement is printed to the command window (see Figure 3-15). Note that modifications to the example APEX run may, in some instances, result in different text being written to the command window during processing.

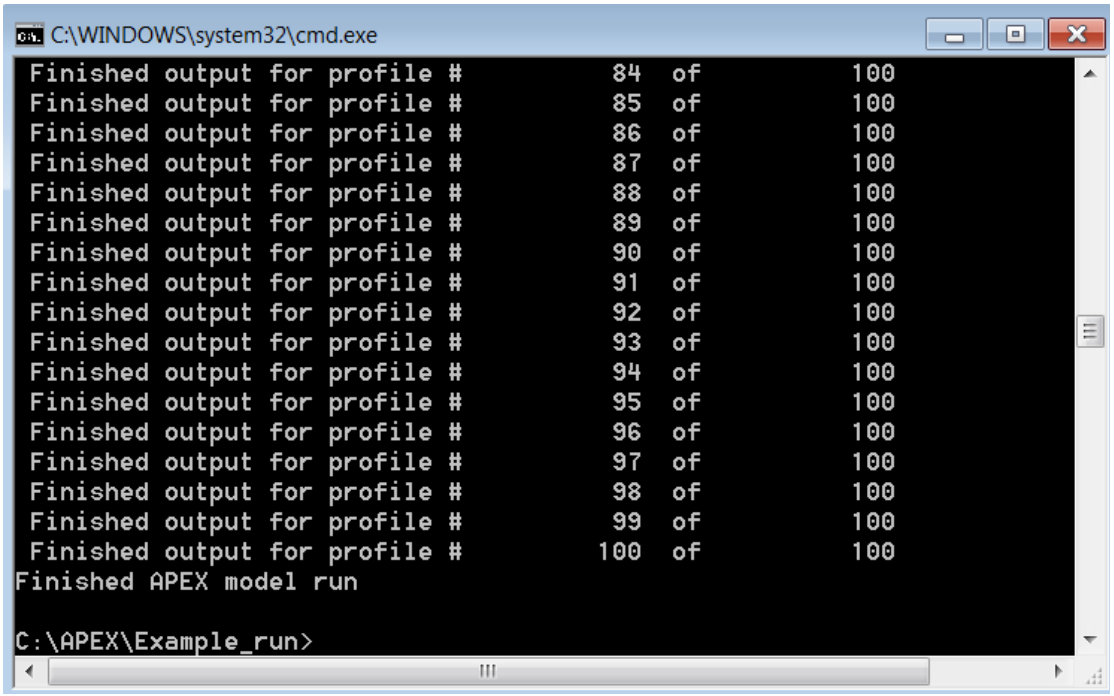


Figure 3-15. Screenshot of Command Prompt Showing that the Example APEX has Completed a Run

The preceding description outlined the steps for running a single APEX simulation. APEX can also be run in what is known as “batch mode” (see also Section 2.1 of UG1). Running APEX in batch mode enables users to run multiple APEX simulations sequentially and automatically.

To prepare to run APEX in batch mode, open a blank text file, and on the first line type the run command discussed earlier in this subsection (full name of the APEX executable file, space, full name of the APEX *COF* for the first simulation; use full directory paths if necessary). On subsequent lines, type the same information for other APEX model runs that are to be part of the batch process (see Figure 3-16).

Once all of the simulations have been enumerated in the text file, save the file with the extension “.bat” (when saving the file, users may need to set the “Save as type” to “All files (*.*)” and manually insert the “.bat” in the file name as the extension). If full file paths for the executables and *COFs* are included in the batch processing file, the file can be saved in any location on the user’s computer; otherwise it must be saved in the same folder as all of the executables and *COFs* that are to be run in the batch process. Once the file is saved in the correct folder with the appropriate extension, close the file. Note that an example “.bat” file named “runAPEX.bat” is provided in the Example_run folder of the installed APEX package.

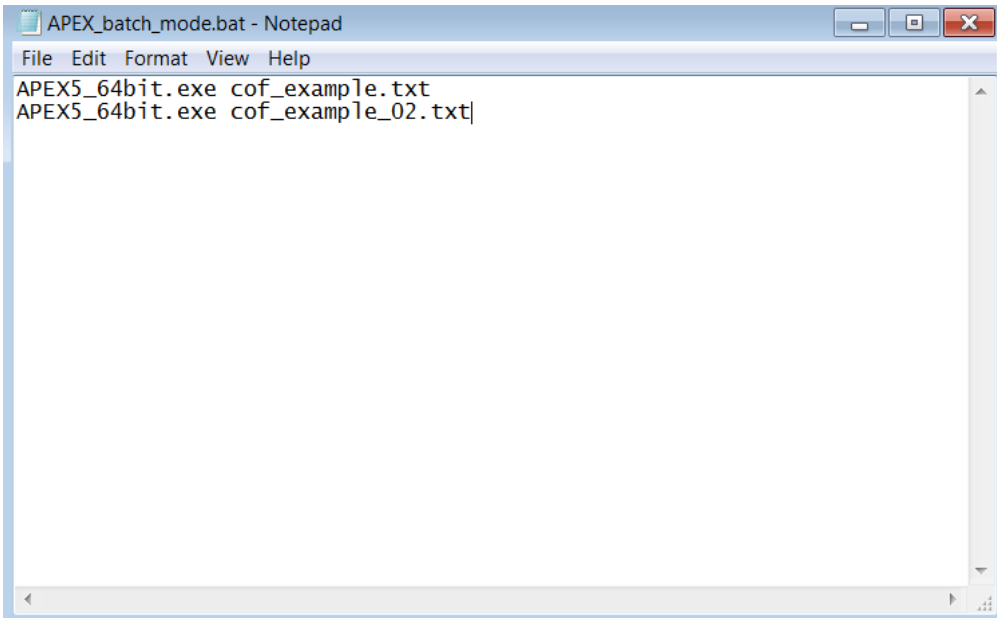


Figure 3-16. Example of an APEX Batch-mode Processing File

Open a command window and set the directory to that containing the APEX batch processing file. Enter the name of the batch processing file and press the “Enter” or “Return” key. The APEX simulations will now be run, one at a time, in the order that was specified in the APEX batch processing file. Alternatively, by double clicking the “.bat” file, a command prompt will automatically open in which the enumerated APEX simulations will begin.

When running APEX in this mode, it is important to remember to either give the output files from each simulation a different name, or to save the output files to separate folders for each simulation. Otherwise, the output files from sequential runs will overwrite those from the previous runs in the batch process. It is also important to remember that double clicking the “.bat” file (or right clicking it and choosing “Open” from the list of options that appears) will cause the contents of the file to be executed and potentially overwrite the outputs of the previous APEX simulations conducted with the file. To edit the contents of a “.bat” file, open the file through a text editor (e.g., Notepad on Windows).

4. Output Files

There are 11 possible output file types, described briefly in Table 4-1, which collectively contain information on the items listed below.

- The demographic characteristics of the simulated profiles
- Hourly or event-level exposures, doses, and physiological data for the simulated profiles
- Hourly or daily values of microenvironmental parameters and pollutant concentrations
- Dose and exposure summary tables for the modeled population
- Exposure statistics for the modeled microenvironments

Table 4-1. APEX Output Files

Output File	Description	Pollutant Specific?[a]	Control File Keyword	User Guide Location for Additional Information
Daily	Daily time series of a user-defined list of APEX variables (e.g., exposure, dose, age, occupation, several microenvironmental settings) for each simulated profile		***DAILY***	UG1, Section 5.4
Events	Summary of physiological information associated with activities in the activity diary, with accompanying exposure and dose, at the diary event level		***EVENT***	UG1, Section 5.10
Hourly	Hourly time series of a user-defined list of APEX variables, including MET, concentrations, and doses, for each simulated profile		***HOUR***	UG1, Section 5.2
Log	Information regarding model run progression		***LOG***	UG1, Section 5.1
Microenvironmental Results	Hourly values for a user-defined list of microenvironment parameters selected (e.g., location and time spent, proximity and penetration factors) for each simulated profile	YES	***MICRORES***	UG1, Section 5.6
Microenvironmental Summary	Summary of time spent in microenvironments and microenvironment air concentrations, for each simulated profile	YES	***MICROSUM***	UG1, Section 5.7

Output File	Description	Pollutant Specific?[a]	Control File Keyword	User Guide Location for Additional Information
Profile Summary (Persons)	Summary of profile characteristics (e.g., demographics, employment and commuting status, physiological characteristics) and pollutant exposure/dose for each simulated profile		***PERSON***	UG1, Section 5.5
Sites	The sectors, air districts, and zones in the study area, and separate mapping between the air districts and sectors and the meteorology zones and sectors		***SITE***	UG1, Section 5.9
Sobol	Sobol analysis attributes all of the differences in exposure and dose between simulated persons to differences in the random variables assigned to them. When Sobol is run, only the *Log*, *Sites*, and *Sobol* files will contain actual output data.		***SOBOL***	UG2, Section 11.2
Output Tables File	See Section 4.5	YES	***TABLESLIST***	UG1, Section 5.8
Timestep File	Similar to the *Hourly* file, but for the user-specified model timestep		***TIMESTEP***	UG1, Section 5.3

[a]If a run with multiple pollutants is designed, files marked 'YES' will be created separately for each pollutant modeled. For the other files, separate columns are created for separate pollutants.

Each of these files is an ASCII file which can be opened and reviewed using a text editor. Except for the top header row indicating the type of output file, all files generated in the same APEX run have identical header rows describing the run. The header is defined as the first set of lines (indicated below) followed by a blank line.

1. Type of output file
2. APEX version; date and time of start run
3. Location description (user-entered value from the *COF*)
4. Scenario description (user-entered value from the *COF*)
5. Echoes first line of the *COF*
6. List of pollutants

7+. Echoes the first line of each *Air Quality Data* file (or, if the output file is pollutant-specific, echoes only the first line of the relevant *Air Quality Data* file)

APEX will overwrite existing output files if they are in the same directory and have the same names. Users should take care to keep separate runs in separate directories and/or with

separate, unique file names. The subsections that follow here discuss a few output files in more detail.

One additional output file that may be of particular interest to users that is not discussed here is the *Events* output file. In this file, event-level information regarding when and where the exposure occurred, as well as more advanced physiology and activity data associated with the particular exposure event, is provided to the user. These options may be specified in the *COF* and can be explored in more depth in the APEX UG1, Section 5.10.

4.1. *Log* File

The *Log* file contains records of the APEX model simulation as the simulation progresses. This file indicates input files and parameter settings used for the simulation, and it reports on many factors. This includes error messages that describe why a simulation was ended prematurely, for example. If a simulation does not complete successfully, users should check the *Log* file for error messages. It is good practice for users to check the *Log* file after the completion of every simulation to examine if the simulation executed and completed properly and if output results are valid.

The *Log* file reports and records the information listed below.

- Input files used
- Settings for job control options
- Model execution time
- Sectors, air districts, and meteorology zones in the study area
- Number of diaries in total, and the number in each diary pool
- Diary activity summary and counts of MET distributions
- Descriptions of the microenvironment-specific parameters
- Statistical summaries of the simulated profiles
- Output summary tables (if requested)

If 40 or fewer profiles are included in the simulation, the profile-level *Log* file will contain each profile's demographic variables and the number of days exceeding the user-defined exposure thresholds for the daily maximum 1-hour table (i.e., the DM1HExp Table).

Users can control the level of detail found in the *Log* file by editing the *COF* parameter **DebugLevel**, which can be set to 0, 1, 2, or 3, with higher levels indicating more information will be written to the *Log*. In addition, users may use the *COF* to select optional switches described in Table 3-2.

An example of a *Log* file can be found in Figure 4-1. The first few lines of this file reiterate the selections or inputs from the user, while the rest of the file explains the information listed above. Figure 4-1 is not a complete view of the *Log* file, as this file contains extensive information on run progression and potential error messages.

```
APEX Log File
APEX Version 5.0 (dated April 10, 2017)  Run Date = 20170411  Time = 061817
Location    = Los Angeles Area
Scenario    = Los Angeles (CSA 348), Jun-Aug 2010 Example case, 2010 pop, RandomSeed 4178348
Simulation  = cof_example.txt from APEX Intro Document Section 3.3; Example APEX model run
Pollutant   =

-------------------------------------------
   Opening input file, unit #           17
   Filename = C:\APEX\Example_run\Air_quality_data_LA_2010.txt
   ! 2010 base ozone air quality data for CSA 348 : Los Angeles-Long Beach-Riverside, CA
   !           59 districts, 01/01/10 to 12/31/10
   ! This file created      September 19, 2016
   ! Rows are days (last entry is the datestamp).
   ! Rows are different daily time separaters (i.e. 30-minute, hourly, etc).
   ! Can input different monitors by specifying "Name = #####".
 Job start   =       1491905897274000

 Location    = Los Angeles Area
 Pollutant   =  Ozone
 Scenario    = Los Angeles (CSA 348), Jun-Aug 2010 Example case, 2010 pop, RandomSeed 4178348
  Start date  =     20100601
  End date    =     20100831

Files used for this run:
Input:
  Simulation          = C:\APEX\Example_run\cof_example.txt
  Pop. Sectors        = C:\APEX\NationalDefaultDatabases\Population_sectors_US_2010.txt
  Air Districts       = C:\APEX\Example_run\Air_districts_LA_2010.txt
  Meteorology Zones   = C:\APEX\Example_run\Meteorology_zones_LA_2010.txt
  Meteorology Data    = C:\APEX\Example_run\Meteorology_data_LA_2010.txt
  Air Quality Data    = C:\APEX\Example_run\Air_quality_data_LA_2010.txt
  MET distributions   = C:\APEX\NationalDefaultDatabases\MET_distributions.txt
  Physiology          = C:\APEX\NationalDefaultDatabases\Physiology.txt
  Ventilation         = C:\APEX\NationalDefaultDatabases\Ventilation.txt
  Employment          = C:\APEX\NationalDefaultDatabases\Employment_US_2010.txt
  Commuting           = C:\APEX\NationalDefaultDatabases\Commuting_flow_US_2010.txt
  Commuting Time      = C:\APEX\NationalDefaultDatabases\Commuting_times_US_2010.txt
  Distributions       = C:\APEX\Example_run\Profile_functions.txt
  Cluster L.Mapping   =
  Location Mapping    = C:\APEX\Example_run\Microenvironment_mappings_05_MEs.txt
```

Note: Only a portion of the file is shown here.

Figure 4-1. Example *Log* File from APEX.

4.2. *Sites* File

The *Sites* file shows which air quality data were mapped to each sector by APEX. This file lists sectors, air districts, and zones present in the study area. It also identifies the mapping between the air districts and sectors, and between meteorology zones and sectors. Each record will contain the information listed below.

- Sector#: Sector ID
  - Latitude and Longitude
  - Sectorname
- Air#: Air district ID
  - Airdistance: Distance between district and sector centroids (km)
  - Airlatitude and Airlongitude: District latitude and longitude
  - Airname: District name

- Met#: Meteorology zone ID
  - Metdistance: Distance between zone and sector centroids (km)
  - Metlatitude and Metlongitude: Zone latitude and longitude
  - Metname: Zone name

An example of a *Sites* file can be found in Figure 4-2. Identifying information for the run is listed at the top of the file. Descriptive information specific to sector ID, district ID, and zone ID are listed in separate columns from left to right, respectively.

```
APEX Sites File
APEX Version 5.0 (dated April 10, 2017)  Run Date = 20170411  Time = 061817
Location    = Los Angeles Area
Scenario    = Los Angeles (CSA 348), Jun-Aug 2010 Example case, 2010 pop, RandomSeed 4178348
Simulation  = cof_example.txt from APEX Intro Document Section 3.3; Example APEX model run
Pollutant   = Ozone
Air Quality = ! 2010 base ozone air quality data for CSA 348 : Los Angeles-Long Beach-Riverside, CA

sector#    latitude   longitude   sectorname  air# airdistance airlatitude airlongitude airname      met# metdistance metlatitude metlongitude metname
      1     34.2595   -118.2930  06037101110     4      9.5110     34.1761   -118.3171  0603710021     2      8.4327     34.2000   -118.3500  2288023152
      2     34.2677   -118.2901  06037101122     4     10.4620     34.1761   -118.3171  0603710021     2      9.3186     34.2000   -118.3500  2288023152
      3     34.2530   -118.2907  06037101210     4      8.8663     34.1761   -118.3171  0603710021     2      8.0216     34.2000   -118.3500  2288023152
      4     34.2516   -118.2816  06037101220     4      8.9910     34.1761   -118.3171  0603710021     2      8.5121     34.2000   -118.3500  2288023152
      5     34.2488   -118.2710  06037101300     4      9.1129     34.1761   -118.3171  0603710021     2      9.0701     34.2000   -118.3500  2288023152
      6     34.2428   -118.2942  06037101400     4      7.7000     34.1761   -118.3171  0603710021     2      7.0046     34.2000   -118.3500  2288023152
      7     34.2251   -118.3542  06037102103     4      6.4190     34.1761   -118.3171  0603710021     2      2.8086     34.2000   -118.3500  2288023152
      8     34.2162   -118.3454  06037102104     4      5.1557     34.1761   -118.3171  0603710021     2      1.8451     34.2000   -118.3500  2288023152
      9     34.2099   -118.3493  06037102105     4      4.7772     34.1761   -118.3171  0603710021     2      1.0969     34.2000   -118.3500  2288023152
     10     34.2409   -118.3395  06037102107     4      7.4799     34.1761   -118.3171  0603710021     2      4.6396     34.2000   -118.3500  2288023152
     11     34.2732   -118.3079  06037103101     4     10.8086     34.1761   -118.3171  0603710021     2      9.0030     34.2000   -118.3500  2288023152
     12     34.2634   -118.3074  06037103102     4      9.7228     34.1761   -118.3171  0603710021     2      8.0523     34.2000   -118.3500  2288023152
     13     34.2734   -118.3402  06037103200     4     10.9959     34.1761   -118.3171  0603710021     2      8.1860     34.2000   -118.3500  2288023152
     14     34.2574   -118.3555  06037103300     4      9.6848     34.1761   -118.3171  0603710021     2      6.3849     34.2000   -118.3500  2288023152
     15     34.2548   -118.3140  06037103400     4      8.7390     34.1761   -118.3171  0603710021     2      6.9299     34.2000   -118.3500  2288023152
     16     34.2821   -118.3926  06037104103     4     13.6606     34.1761   -118.3171  0603710021     2      9.9157     34.2000   -118.3500  2288023152
     17     34.2762   -118.4047  06037104105     4     13.7220     34.1761   -118.3171  0603710021     2      9.8353     34.2000   -118.3500  2288023152
     18     34.2732   -118.3986  06037104108     4     13.1241     34.1761   -118.3171  0603710021     2      9.2662     34.2000   -118.3500  2288023152
     19     34.2902   -118.3739  06037104124     4     13.7015     34.1761   -118.3171  0603710021     2     10.2501     34.2000   -118.3500  2288023152
     20     34.2865   -118.4161  06037104201     6     14.4616     34.1993   -118.5328  0603712011     2     11.3641     34.2000   -118.3500  2288023152
     21     34.2791   -118.4116  06037104203     6     14.2493     34.1993   -118.5328  0603712011     2     10.4434     34.2000   -118.3500  2288023152
     22     34.2913   -118.3931  06037104204     4     14.5710     34.1761   -118.3171  0603710021     2     10.8775     34.2000   -118.3500  2288023152
     23     34.2764   -118.4293  06037104310     6     12.8077     34.1993   -118.5328  0603712011     2     11.1853     34.2000   -118.3500  2288023152
     24     34.2731   -118.4202  06037104320     6     13.2132     34.1993   -118.5328  0603712011     2     10.3774     34.2000   -118.3500  2288023152
     25     34.2670   -118.4327  06037104401     6     11.8945     34.1993   -118.5328  0603712011     2     10.6482     34.2000   -118.3500  2288023152
     26     34.2588   -118.4345  06037104403     6     11.2059     34.1993   -118.5328  0603712011     2     10.1534     34.2000   -118.3500  2288023152
     27     34.2639   -118.4287  06037104404     6     11.9744     34.1993   -118.5328  0603712011     2     10.1409     34.2000   -118.3500  2288023152
     28     34.2555   -118.4257  06037104500     6     11.6691     34.1993   -118.5328  0603712011     2      9.3072     34.2000   -118.3500  2288023152
     29     34.2604   -118.4190  06037104610     6     12.4878     34.1993   -118.5328  0603712011     2      9.2388     34.2000   -118.3500  2288023152
     30     34.2579   -118.4225  06037104620     6     12.0665     34.1993   -118.5328  0603712011     2      9.2643     34.2000   -118.3500  2288023152
     31     34.2685   -118.4152  06037104701     6     13.2753     34.1993   -118.5328  0603712011     2      9.6842     34.2000   -118.3500  2288023152
     32     34.2552   -118.4006  06037104703     4     11.6721     34.1761   -118.3171  0603710021     2      7.6981     34.2000   -118.3500  2288023152
```

Note: Only a portion of the file is shown here.

Figure 4-2. An Example *Sites* File from APEX

4.3. *Profile Summary* File

The *Profile Summary* file (also referred to as a *Person Summary* file) provides a summary of each profile modeled within APEX. This includes information on age, sex, race, and other personal profile variables, all of which are used to inform the exposure simulation. Users can control which variables are written to this file by using the ***PSumList*** parameter in the *COF* (see Table 3-2).

The mandatory (not optional) variables written in this file are described in Table 4-2. For more information on optional variables, see UG1, Section 5.5. Optional outputs include information on numbers of diaries and events, commuting, usage of air conditioning and natural gas, profile and regional conditional variables, variables related to carbon monoxide exposure, MET, respiration, exposure, and dose.

Table 4-2. APEX Variables Written to the *Profile Summary* File

Variables	Description
Person	Sequential index number for the simulated profile
Home Sector	Sector in which the person lives (home)
Work Sector	Sector in which the person works (=home sector for non-workers)
Home District	Air district for the home sector
Work District	Air district for the work sector
Zone	Meteorology zone for the home sector
Age	Age of the simulated profile (years)
Gender[a]	Male or female
Race	e.g., White, Black, Asian, Hispanic, Native American (NatAm), Other (depending on *Population Data* input files)
Employment	Indicates employment outside the home (Y or N)
Height	Height (inches) of the simulated profile
Weight	Body mass (pounds) of the simulated profile

Note: Only the mandatory output variables are shown here; optional variables are not shown.
[a]The APEX model (i.e., source code, inputs, outputs) might use "gender" rather than "sex" but they are intended to be synonymous. Future versions of APEX may replace "gender" with "sex."

An example of a *Profile Summary* file can be found in Figure 4-3. Identifying information for the run is listed at the top of the file. Subsequent rows describe each person in the simulated population as well as the corresponding information on the 12 variables listed in Table 4-2. Note in particular that people can work in their home tract. For example, in Figure 4-3, profile 29 both lives and works in sector #800. When the *COF* has commuting set to no, then all workers are automatically set to work in their home tract.

4.4. *Microenvironmental Results* File

The *Microenvironmental Results* file contains information regarding the “home,” “work,” or “other” microenvironments specified by the user, as well as the “road,” “road work,” “near home,” and “near work” locations if specified. Per pollutant and per location, this file contains a summary table with information such as an hour-by-hour time series of microenvironment pollutant concentrations and pollutant parameters for each modeled profile. Users should note that this file describes the air concentrations in the microenvironments, regardless of whether the profile was in a given microenvironment at the specified time. If the user chooses to write the microenvironmental results file for all pollutants, the *COF* parameter ***MResOut*** should be set to **Y** (yes; see Table 3-2). The default is **N** (no) in order to improve simulation speed. The mandatory (not optional) variables are described in Table 4-3.

```
APEX Personal Summary File
APEX Version 5.0 (dated April 10, 2017)  Run Date = 20170411  Time = 061817
Location    = Los Angeles Area
Scenario    = Los Angeles (CSA 348), Jun-Aug 2010 Example case, 2010 pop, RandomSeed 4178348
Simulation  = cof_example.txt from APEX Intro Document Section 3.3; Example APEX model run
Pollutant   = Ozone
Air Quality = ! 2010 base ozone air quality data for CSA 348 : Los Angeles-Long Beach-Riverside, CA

P HSect WSect HDis WDis Zone Age Gender Race Empl Height Weight
      1     850   850   3   3   3  23 M White Y 70.622 155.506
      2    2759  2759  16  16   4  17 M White N 62.405  98.362
      3     221   127   6   6   2  25 M  Hisp Y 66.647 167.546
      4     245   245   6   6   2  16 M Black N 69.744 148.707
      5    2659  2636  17  17   4  56 F  Hisp Y 64.617 155.805
      6    2642  2682  17  17   4  34 M  Hisp Y 66.938 137.209
      7    2710  2567  16  17   4  36 M White Y 66.486 179.077
      8     598  2144   5  13   2  32 M Black Y 74.469 232.043
      9     418   418   4   4   2  74 M Other N 71.349 253.191
     10    2581  2488  18  18   4  40 M White Y 69.272 174.274
     11     894   894   3   3   3  21 M White N 68.112 135.083
     12    1642  1642   7   7   4  59 F  Hisp N 59.222 119.232
     13    1509  1509  19  19   4   6 F  Hisp N 47.590  49.878
     14     178  1032   4   4   2  33 F  Hisp Y 61.713 115.161
     15    2797  2636  16  17   4  22 F  Hisp Y 63.500 178.299
     16    2172   691  15   5   5  26 F  Hisp Y 61.352 135.588
     17    2959  2959  29  29   1  63 F White N 61.611 140.969
     18     739   739   5   5   3  15 F  Hisp N 65.243 132.493
     19    3515  3515  36  36   1  32 M Black Y 68.980 246.076
     20    2412   207  19   4   4  37 F  Hisp Y 65.541 300.830
     21    1852  1937  11  11   4  50 F Black Y 66.857 133.699
     22    2431  2431  16  16   4  60 F Asian N 60.609 179.151
     23     774   774   7   7   3  78 M  Hisp N 69.467 187.964
     24    1363   108  10   6   2  57 M Black Y 67.152 137.260
     25     310   295   6   6   2  45 M White Y 69.102 210.260
     26    3502  3502  36  36   1  16 M  Hisp N 62.819 124.331
     27    3841  3841  41  41   6  63 F White N 66.593 228.793
     28     303   394   6   4   2  35 M Black Y 72.268 209.932
     29     800   800   7   7   3  19 M  Hisp N 68.534 120.111
     30    2738  1488  16   8   4  44 F  Hisp Y 70.309 175.721
     31    2178  2178  15  15   5  30 M White N 72.827 216.178
     32     961   269  12   6   4  49 M  Hisp Y 69.937 207.720
```

Note: Only a portion of the file is shown here.

Figure 4-3. An Example of *Personal Summary* File from APEX.

Users are able to specify which optional variables should be output to the *Microenvironmental Results* file by using the ***MResList*** parameter in the *COF* (see Table 3-2). For more information on optional variables, see UG1, Section 5.6. Optional outputs include information on district, microenvironmental proximity, penetration, air-exchange, and decay factors, ambient and microenvironmental concentrations, window usage, daily and air-quality conditional variables, and meteorology conditions.

An example of a *Microenvironmental Results* file (home microenvironment only) can be found in Figure 4-4. Identifying information for the run is listed at the top of the file. Identifying information on ***Micro#***, ***Location*** (Loc), and ***Hour*** are provided per profile for each “step”. These steps are single hours describing the profiles microenvironment, hour-by-hour, over the course of the simulation.

Table 4-3. APEX Variables Written to the *Microenvironmental Results* File

Variable	Description
Person	Sequential index number for the simulated profile
Hour #	Hour of the simulation. Hour ranges from -23 up 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.
Micro #	Microenvironment number: a character variable that assigns the location code as belonging to a "Home," "Work," "Other," "Road," "Road Work," "Near Work," "Near Home," "Last," or "Unknown" location (the codes are H/W/O/R/RW/NW/NH/L/U, respectively)
Location	APEX calculates concentrations for each microenvironment including: home (1), work (2), other (3), roadway (4), near home (5), near work (6), road work (7), and near last (99) locations (see UG2). Any locations that are used are listed in the file.

Note: Only the mandatory output variables are shown here; optional variables are not shown.

```
APEX Microenvironmental Results File
APEX Version 5.0 (dated April 10, 2017)  Run Date = 20170411  Time = 061817
Location    = Los Angeles Area
Scenario    = Los Angeles (CSA 348), Jun-Aug 2010 Example case, 2010 pop, RandomSeed 4178348
Simulation  = cof_example.txt from APEX Intro Document Section 3.3; Example APEX model run
Pollutant   = Ozone
Air Quality = ! 2010 base ozone air quality data for CSA 348 : Los Angeles-Long Beach-Riverside, CA
Simulation Start Date = 20100601

Person Micro Loc  Hour  Step Prx Pen Amb Conc AER RR Day Month District  DayWeek
     1  1 1  -23  -23 1.0000 1.0000 3.100E-02 4.708E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -22  -22 1.0000 1.0000 3.400E-02 7.191E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -21  -21 1.0000 1.0000 3.400E-02 7.482E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -20  -20 1.0000 1.0000 3.600E-02 7.800E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -19  -19 1.0000 1.0000 3.500E-02 7.779E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -18  -18 1.0000 1.0000 3.350E-02 7.492E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -17  -17 1.0000 1.0000 3.200E-02 7.163E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -16  -16 1.0000 1.0000 3.300E-02 7.213E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -15  -15 1.0000 1.0000 3.800E-02 8.033E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -14  -14 1.0000 1.0000 4.000E-02 8.666E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -13  -13 1.0000 1.0000 4.200E-02 9.116E-03  0.6755  1.7669   1  6     3 3
     1  1 1  -12  -12 1.0000 1.0000 4.700E-02 1.001E-02  0.6755  1.7669   1  6     3 3
     1  1 1  -11  -11 1.0000 1.0000 5.300E-02 1.126E-02  0.6755  1.7669   1  6     3 3
     1  1 1  -10  -10 1.0000 1.0000 5.900E-02 1.258E-02  0.6755  1.7669   1  6     3 3
     1  1 1   -9   -9 1.0000 1.0000 5.700E-02 1.268E-02  0.6755  1.7669   1  6     3 3
     1  1 1   -8   -8 1.0000 1.0000 5.400E-02 1.212E-02  0.6755  1.7669   1  6     3 3
     1  1 1   -7   -7 1.0000 1.0000 5.100E-02 1.146E-02  0.6755  1.7669   1  6     3 3
     1  1 1   -6   -6 1.0000 1.0000 4.900E-02 1.095E-02  0.6755  1.7669   1  6     3 3
     1  1 1   -5   -5 1.0000 1.0000 4.700E-02 1.051E-02  0.6755  1.7669   1  6     3 3
     1  1 1   -4   -4 1.0000 1.0000 4.600E-02 1.022E-02  0.6755  1.7669   1  6     3 3
     1  1 1   -3   -3 1.0000 1.0000 4.300E-02 9.690E-03  0.6755  1.7669   1  6     3 3
     1  1 1   -2   -2 1.0000 1.0000 3.900E-02 8.883E-03  0.6755  1.7669   1  6     3 3
     1  1 1   -1   -1 1.0000 1.0000 3.800E-02 8.460E-03  0.6755  1.7669   1  6     3 3
     1  1 1    0    0 1.0000 1.0000 3.700E-02 8.231E-03  0.6755  1.7669   1  6     3 3
     1  1 1    1    1 1.0000 1.0000 3.100E-02 7.250E-03  0.6755  1.7669   1  6     3 3
     1  1 1    2    2 1.0000 1.0000 3.400E-02 7.310E-03  0.6755  1.7669   1  6     3 3
     1  1 1    3    3 1.0000 1.0000 3.400E-02 7.488E-03  0.6755  1.7669   1  6     3 3
     1  1 1    4    4 1.0000 1.0000 3.600E-02 7.800E-03  0.6755  1.7669   1  6     3 3
     1  1 1    5    5 1.0000 1.0000 3.500E-02 7.779E-03  0.6755  1.7669   1  6     3 3
     1  1 1    6    6 1.0000 1.0000 3.350E-02 7.492E-03  0.6755  1.7669   1  6     3 3
     1  1 1    7    7 1.0000 1.0000 3.200E-02 7.163E-03  0.6755  1.7669   1  6     3 3
```

Note: Only a portion of the file is shown here.

Figure 4-4. An Example *Microenvironmental Results* File from APEX.

4.5. *Output Tables* File

There are hundreds of possible output tables that APEX can generate and print to the *Output Tables* file. The list of tables that is printed in an APEX run is the result of the combinations of user-defined specifications set using the ***TablesList*** parameter in the *COF* (see Table 3-2). The tables can display information summarizing things like exposure, dose, or time spent at or above a certain exposure threshold level on various time scales. These metrics can be summarized on the basis of delineations including profiles with an illness, profiles that are defined as "active", profiles that experience certain exertion levels, profiles that are employed, etc. Users do *not* specify each individual table that will be printed out. Rather, APEX analyzes the values defined in the ***TablesList*** parameter and determines all of the tables whose contents align with these specifications.

As an example, if the ***TablesList*** parameter is set only to "EXP1H" (which tells APEX to print tables pertinent to 1-hour exposures), a total of two tables will be printed to the *Output Tables* file: a table denoting the person-days at or above each daily maximum 1-hour exposure level, and a table denoting the number of simulated persons with multiple exposures at or above each daily maximum 1-hour exposure level. Both of these tables contain data for the entire population.

If, however, the user sets the ***TablesList*** parameter to the value "EXP1H ILLNESS" (which tells APEX to print tables pertinent to 1-hour exposures *and* tables pertinent to profiles with the user-defined illness; see Section 3.2.1.7), then a total of four tables will be printed out: the same two tables that were printed when ***TablesList*** was set to just "EXP1H", as well as these same two tables with data for the subgroup of individuals with the defined illness. If the user does not specify the ***TablesList*** parameter, the *Output Tables* file will be generated, but only header information (with no tables) will be printed to the file. Users should examine the list of possible settings for the ***TablesList*** parameter above (or below) to determine the correct list necessary to produce the desired tables.

There are many output tables that the user can create based on specifications made in the *COF* using the ***TablesList*** parameter. This parameter takes the arguments described below.

- EXP1H, EXP8H, EXPTS, EXPAVG: prints the tables pertaining to the 1-hour, 8-hour, time-step maxima, and average daily exposures (in user-defined units, ***OutputUnits***)
- DOSE1H, DOSE8H, DOSETS, DOSE1EH, DOSEAVG: prints the tables pertaining to the 1-hour, 8-hour, time-step, 1-hour end-of-hour maxima, and average daily doses. Dose units depend on the pollutant.
- MICROTIME: prints the time spent in each microenvironment (minutes)
- DOSETIME: prints the time spent in each dose category (minutes)
- CHILDREN: prints additional tables that include only children
- ACTIVE, ACTCHILD: prints tables including active individuals, or the subset of active children

- ILLNESS, ILLCHILD: prints tables that include the subgroup of those profiles with the user-specified illness, for all simulated individuals or children only
- MOD, HEAVY: prints the tables for individuals on days in the moderate or heavy equivalent ventilation rate (EVR) categories
- EMPLOYED: prints tables for all employed persons

Depending on the specifications chosen by the user in the ***TablesList*** parameter, the tables corresponding to some (or all) of the seven subgroup populations and three exertion levels listed above will be generated.

Additionally, APEX can write out exposure summary tables, dose summary tables, or response probability tables. These output tables summarize results of the simulation per pollutant, meaning that one *Output Tables* file will be created for each pollutant, each containing the user-specified tables. Entries defined by the user in the *COF* determine exposure or dose thresholds or percentiles.

Four particular exposure summary tables are discussed below, but more information about additional output table options can be found in UG1, Section 5.8. There are parameters in the *COF* that users can engage to specify the exposure concentration ranges for the exposure tables, but the cut-points themselves are defined for different situational settings (such as hourly exposure, 8-hourly exposure, daily-averaged exposure, etc.). These are parameters like ***TimeExp, DM1HExp, DM8Hexp, TSMulti***, etc. Users should reference Table 3-2, particularly the “Pollutant Parameters (Advanced)” section of the table, where the various parameters used for defining the Output Tables cut-points are explained.

4.5.1. Exposure Table Type #1: Minutes in each exposure interval by microenvironment

This table provides the information listed below, for each microenvironment and range of exposure concentration specified by the user.

- Minutes: the total minutes spent by all simulated profiles in each microenvironment when the exposure concentration is within various specified ranges
- Row_%: of all minutes spent in the microenvironment, the percent of minutes within each range of exposure concentration (totaling 100 percent per microenvironment)
- Tot_%: of all minutes spent in any of the microenvironments and ranges of exposure concentrations, the percent of minutes within each microenvironmental and concentration range (totaling 100 percent across the whole table)

This type of table is generated only once for the entire population profiles under all exertion conditions. Each table generated by APEX has a label printed that identifies the table uniquely. For table type #1, the identifier TIME,WITHIN,ALL,ALL,ALL is used.

Figure 4-5 below shows the Exposure Table Type #1 output from the example run in Section 3. As described, each summary is provided per microenvironment. Descriptions per microenvironment are provided for the three values summarized above, with the upper range of exposure described by the associated column label and the lower range of exposure described by the column title immediately to the left. Various ranges of exposure concentrations are therefore described, specific to each microenvironment, and summarized over the entire population of profiles.

TIME,WITHIN,ALL,ALL,ALL
Exposure: Minutes in each Exposure interval (ppm), by microenvironment, for N = 100 Profiles

Micro	Level:	0.0000	0.0100	0.0200	0.0300	0.0400	0.0500	0.0600
0	Minutes	8956.	0.	0.	0.	0.	0.	0.
0	Row_%	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0	Tot_%	0.0676	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	Minutes	6779631.	1521135.	399991.	137961.	55724.	21816.	5893.
1	Row_%	75.9771	17.0469	4.4826	1.5461	0.6245	0.2445	0.0660
1	Tot_%	51.1748	11.4820	3.0193	1.0414	0.4206	0.1647	0.0445
2	Minutes	117196.	261742.	429532.	543993.	403364.	267779.	150103.
2	Row_%	5.1158	11.4255	18.7497	23.7462	17.6075	11.6890	6.5522
2	Tot_%	0.8846	1.9757	3.2422	4.1062	3.0447	2.0213	1.1330
3	Minutes	29180.	50405.	107520.	159205.	170616.	161527.	121141.
3	Row_%	3.1461	5.4345	11.5925	17.1651	18.3954	17.4154	13.0611
3	Tot_%	0.2203	0.3805	0.8116	1.2017	1.2879	1.2193	0.9144
4	Minutes	11490.	18978.	33252.	52074.	61248.	68565.	46668.
4	Row_%	3.4175	5.6447	9.8902	15.4884	18.2171	20.3934	13.8805
4	Tot_%	0.0867	0.1433	0.2510	0.3931	0.4623	0.5175	0.3523
5	Minutes	52073.	66529.	87744.	98727.	105503.	146289.	109987.
5	Row_%	6.8408	8.7399	11.5269	12.9697	13.8599	19.2180	14.4490
5	Tot_%	0.3931	0.5022	0.6623	0.7452	0.7964	1.1042	0.8302

Note: Only a portion of the table is shown here.

Figure 4-5. Example Screenshot of Exposure Table Type #1 from APEX

4.5.2. Exposure Table Type #2: Minutes at or above each exposure level by microenvironment

This table is similar to Exposure Table Type #1, except that it reports cumulative person-minutes spent in the microenvironment when the exposure concentration is at or above the value indicated at the top of the column. The identifier for Exposure Table Type #2 is TIME,ATABOVE,ALL,ALL,ALL.

Figure 4-6 below shows the Exposure Table Type #2 output from the example run in Section 3. This figure is nearly identical to Figure 4-5, though the interpretation of the column titles is slightly different. In Exposure Table Type #2, row values represent information associated with exposure concentrations at or above the value indicated in the column title.

TIME,ATABOVE,ALL,ALL,ALL
Exposure: Minutes at or above each Exposure Level (ppm), by microenvironment, for N = 100 Profiles

	Level:	0.0000	0.0100	0.0200	0.0300	0.0400	0.0500	0.0600
Micro								
0	Minutes	8956.	0.	0.	0.	0.	0.	0.
0	Row_%	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0	Tot_%	0.0676	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	Minutes	8923261.	2143630.	622495.	222504.	84543.	28819.	7003.
1	Row_%	100.0000	24.0229	6.9761	2.4935	0.9474	0.3230	0.0785
1	Tot_%	67.3555	16.1808	4.6988	1.6795	0.6382	0.2175	0.0529
2	Minutes	2290868.	2173672.	1911930.	1482398.	938405.	535041.	267262.
2	Row_%	100.0000	94.8842	83.4588	64.7090	40.9629	23.3554	11.6664
2	Tot_%	17.2922	16.4075	14.4318	11.1896	7.0834	4.0387	2.0174
3	Minutes	927493.	898313.	847908.	740388.	581183.	410567.	249040.
3	Row_%	100.0000	96.8539	91.4193	79.8268	62.6617	44.2663	26.8509
3	Tot_%	7.0010	6.7807	6.4003	5.5887	4.3869	3.0991	1.8798
4	Minutes	336212.	324722.	305744.	272492.	220418.	159170.	90605.
4	Row_%	100.0000	96.5825	90.9379	81.0477	65.5592	47.3422	26.9488
4	Tot_%	2.5378	2.4511	2.3079	2.0569	1.6638	1.2015	0.6839
5	Minutes	761210.	709137.	642608.	554864.	456137.	350634.	204345.
5	Row_%	100.0000	93.1592	84.4193	72.8924	59.9226	46.0627	26.8448
5	Tot_%	5.7458	5.3528	4.8506	4.1883	3.4431	2.6467	1.5425

Note: Only a portion of the table is shown here.

Figure 4-6. Example Screenshot of Exposure Table Type #2 from APEX

4.5.3. Exposure Table Type #3: Person-days at or above each daily maximum 1-hour exposure level

This table provides summaries of the cumulative person-days that simulated persons are at or above various daily maximum 1-hour exposure levels specified by the user in the *COF*.

This type of table can be generated for up to seven population subgroups (described in the table header row “Group:”), at up to three different exertion levels. These subgroups can be specified by the user, as described below.

- Population subgroups (7):
  - All people (entire modeled population)
  - Children (between ***ChildMin*** and ***ChildMax*** defined in the *COF*)
  - Active persons (profiles with median PAIs over the whole simulation that exceed ***ActivePAI*** defined in the *COF*)
  - Active children (based on *COF* values ***ChildMin***, ***ChildMax***, and ***ActivePAI***)
  - Ill Persons (determined by probabilities in *Prevalence* file; the ***Disease*** variable must be set in the *COF*)
  - Ill Children (like Ill Persons, but for children between ***ChildMin*** and ***ChildMax*** defined in the *COF*)
  - Employed persons (based on population of all employed people)
- Exertion levels (3):
  - All exertion conditions (exposures during all ventilation conditions)
  - Moderate exertion (exposures experienced only when average equivalent ventilation rate, EVR, in the “moderate” range, defined in the *COF* as at least ***ModEVR1*** and less

than ***HeavyEVR1*** if the user selects 1-hour averaging, or at least ***ModEVR8*** and less than ***HeavyEVR8*** if 8-hour averaging is selected)

- Heavy exertion (exposures experienced only when the average EVR is in the "heavy" range, defined in the *COF* as at least ***HeavyEVR1*** if the user selects 1-hour averaging or at least ***HeavyEVR8*** if the user selects 8-hour averaging)

The row values seen in Figure 4-7 are summarized below, specific to the specified population subgroup at the specified exertion level. More detail is available in UG1, Section 5.8.

- Counts (Pop): person-days at or above the daily maximum 1-hour exposure level (defined at the top of each column)
- #Meet (Pop) and %Meet (Pop): number and percent of persons in the study area population who have at least one exposure at or above the daily maximum 1-hour exposure level
- Mean, Std. Dev, and CV: mean, standard deviation, and coefficient of variation in the number of days per profile during which an exposure is at or above the daily maximum 1-hour exposure level
- Minimum, Percentiles, and Maximum: the lowest, nth percentile, and maximum total number of days during which an exposure is at or above the daily maximum 1-hour exposure level
- Mean (%), Min (%), and Max (%): mean, minimum, and maximum number of days per profile during which an exposure is at or above the daily maximum 1-hour exposure level, as percentage of possible days
- Counts (Sim): total number of simulated person-days during which an exposure is at or above the daily maximum 1-hour exposure level
- #Meet (Sim): total number of simulated profiles who experience at least one exposure at or above the daily maximum 1-hour exposure level

The identifier for Exposure Table Type #3 is PERSONDAYS,DM1H,ALL,ALL,ALL.

Figure 4-7 below shows the Exposure Table Type #3 output from the example run in Section 3. As discussed above, the row values correspond to information associated with the simulated population when they are at or above various daily maximum 1-hour exposure levels specified by the user.

```
76  PERSONDAYS,DM1H,ALL,ALL,ALL
77  Exposure: Person-Days at or above each Daily Maximum 1-Hour Exposure Level ( ppm ), for N =     100 Prof
78  Group: All People
79
80     Level:          0.00000      0.01000      0.02000      0.03000      0.04000      0.05000      0.06000
81  ---------------------------------------------------------------------------------------------------------
82   Counts(Pop):    1.520E+09    1.500E+09    1.468E+09    1.422E+09    1.317E+09    1.047E+09    6.575E+08
83   #Meet (Pop):     16519458     16519458     16519458     16519458     16519458     16519458     16519458
84   %Meet (Pop):       100.000      100.000      100.000      100.000      100.000      100.000      100.000
85   Mean       :        92.000       90.830       88.870       86.090       79.720       63.380       39.800
86   Std.Dev.   :         0.000        3.219        5.834        8.250       11.029       13.949       16.551
87   CV         :         0.000        0.035        0.066        0.096        0.138        0.220        0.416
88   Minimum    :        92.000       69.000       61.000       56.000       45.000       28.000        8.000
89    5.0 %ile  :        92.000       87.050       78.000       66.100       56.100       41.050       17.000
90   10.0 %ile  :        92.000       89.000       83.100       71.000       60.100       44.100       20.200
91   15.0 %ile  :        92.000       89.150       85.000       78.150       65.450       49.150       24.000
92   20.0 %ile  :        92.000       91.000       87.000       85.000       71.600       51.000       25.200
93   25.0 %ile  :        92.000       91.000       88.000       86.000       77.000       53.250       28.000
94   30.0 %ile  :        92.000       91.000       90.000       87.000       78.000       55.300       29.300
95   35.0 %ile  :        92.000       92.000       90.350       87.350       79.000       58.000       31.350
96   40.0 %ile  :        92.000       92.000       91.000       88.000       80.400       59.000       33.000
97   45.0 %ile  :        92.000       92.000       91.000       88.000       82.000       61.000       34.450
98   50.0 %ile  :        92.000       92.000       91.000       89.000       83.000       64.000       36.500
99   55.0 %ile  :        92.000       92.000       91.000       90.000       84.000       66.550       39.550
100  60.0 %ile  :        92.000       92.000       92.000       90.600       84.600       68.000       42.000
101  65.0 %ile  :        92.000       92.000       92.000       91.000       86.000       68.000       43.650
102  70.0 %ile  :        92.000       92.000       92.000       91.000       87.000       70.700       45.000
103  75.0 %ile  :        92.000       92.000       92.000       91.000       88.000       74.000       47.750
104  80.0 %ile  :        92.000       92.000       92.000       92.000       88.000       75.000       51.800
105  85.0 %ile  :        92.000       92.000       92.000       92.000       89.850       79.850       55.850
106  90.0 %ile  :        92.000       92.000       92.000       92.000       90.900       82.000       66.900
107  95.0 %ile  :        92.000       92.000       92.000       92.000       91.950       86.950       73.950
108  99.0 %ile  :        92.000       92.000       92.000       92.000       92.000       91.000       83.980
109  Maximum    :        92.000       92.000       92.000       92.000       92.000       91.000       84.000
110  Mean   (%) :       100.000       98.728       96.598       93.576       86.652       68.891       43.261
111  Min    (%) :       100.000       75.000       66.304       60.870       48.913       30.435        8.696
112  Max    (%) :       100.000      100.000      100.000      100.000      100.000       98.913       91.304
113  Counts(Sim):  9.200E+03    9.083E+03    8.887E+03    8.609E+03    7.972E+03    6.338E+03    3.980E+03
114  #Meet (Sim):          100          100          100          100          100          100          100
115  ---------------------------------------------------------------------------------------------------------
```

Note: Only a portion of the table is shown here.

Figure 4-7. Example Screenshot of Exposure Table Type #3 from APEX

4.5.4. Exposure Table Type #6: Number of simulated profiles with multiple exposures at or above each daily maximum 1-hour exposure level

This table creates a count of simulated profiles who experience multiple exposures (i.e., at least 1, 2, 3, 4, 5, or 6 days) at or above the daily maximum 1-hour exposure levels defined by the user in the *COF*. Similar to Exposure Table Type #3, this output table can be generated for seven possible population subgroups under three possible exertion levels.

The identifier for Exposure Table Type #6 is MULTIPLE,DM1H,ALL,ALL,ALL.

Figure 4-8 below shows the Exposure Table Type #6 output from the example run in Section 3. Each row represents the level of maximum 1-hour exposure, while each column counts the number of profiles that experience that number of exposures over the APEX simulation.

MULTIPLE,DM1H,ALL,ALL,ALL
Exposure: Number of Simulated Persons with Multiple Exposures at or above each Daily
Group: All People

Level	At least 1 Exposure	At least 2 Exposures	At least 3 Exposures	At least 4 Exposures	At least 5 Exposures	At least 6 Exposures
0.000	100	100	100	100	100	100
0.010	100	100	100	100	100	100
0.020	100	100	100	100	100	100
0.030	100	100	100	100	100	100
0.040	100	100	100	100	100	100
0.050	100	100	100	100	100	100
0.060	100	100	100	100	100	100
0.070	100	99	99	98	94	93
0.080	96	86	83	76	68	58
0.090	82	65	47	31	24	22
0.100	49	32	17	13	9	5
0.110	28	10	3	1	1	0
0.120	7	1	0	0	0	0
0.130	2	0	0	0	0	0
0.140	1	0	0	0	0	0
0.150	0	0	0	0	0	0
0.160	0	0	0	0	0	0

Note: Only a portion of the file is shown here.

Figure 4-8. Example Screenshot of Exposure Table Type #6 from APEX

4.6. Post-processing Options

While tables in the *Output Tables* file are already formatted for ease of use, post-processing is necessary if summaries of other output files are desired. In Appendix A.1 and Appendix A.2 of this document, scripts for reading the output files are available in R and SAS, respectively. These scripts pertain to the *Daily*, *Events*, *Hourly*, *Profile Summary*, *Sites*, and *Timestep* output files. Users should edit these programs as appropriate to reflect the specific details of their outputs. The scripts available in these appendices can be used with the example run found in Section 3.

5. Variations on Typical Runs

Users of APEX have many options for the variations they can apply to the simulation. For example, users can modify or provide their own input files, though they must be correctly formatted for APEX to read. Input files can be edited using a text editor.

Keyword and/or input values are generally not case-sensitive in the input files, unless otherwise noted in UG1 or UG2. Generally, each line of an input file is processed independently by APEX (please see Section 3 for caveats to this statement, which includes the ***County*** parameter, the ***Tract*** parameter, and the ***Pollutant*** parameter). This means that, generally, specific parameters do not have to be defined on a specific line number. Also, for a parameter with a series of values, the values should generally be separated (i.e., delimited) by a blank or a comma (some input files require a particular delimiter). Note in particular that words on numeric and character input lines should not contain internal blanks, as these will be interpreted as delimiters between input fields. Keyword lines, however, may contain internal blanks as there are only two fields associated with these lines (the field to the left and the field to the right of the "=" sign). Because each line is processed independently, this also means that continuations of data values across multiple lines are not permitted, unless specifically noted for a particular file.

Each line of the input files falls into one of the four categories listed below.

1. Keyword (or variable, or parameter) line: Format is KEYWORD = VALUE. This type of line may indicate where an input file is located, or it may assign value to a variable. Keywords are used to identify and set the input values. The keyword must start with a letter and match spelling sought by program code, after which it may include additional letters, blanks, or commas. Values can be characters, logicals, numeric values, or file names.

2. Numeric line: Any line beginning with a digit (0–9). Non-digits may appear later in a numeric line.

3. Character line: Any line beginning with a character and not containing an "=".

4. Comment line: Any blank line or line beginning with "!", which can be used by the user to help document the file. A comment line is not acted on in the model. These should not be inserted in the middle of a block of data, though can be added where necessary to appropriately document the file.

We discuss below particular variations on APEX runs that may be of interest to new users of APEX.

5.1. Customizing and Modifying Input Files

Users may wish to customize input files with their own data or with alternate values. As mentioned above, particular attention should be paid to the format of these files. Below are a

few input files, as well as the requirements for modifications, that may be of interest to new users of APEX.

5.1.1. *Microenvironment Descriptions* File

The *Microenvironment Descriptions* input file defines the microenvironments to be modeled and specifies the methods by which pollutant concentrations are calculated in each microenvironment. This file also defines the probability distributions of the microenvironment parameters that are required to calculate these concentrations. The microenvironment parameters include air exchange rate, decay rate, proximity, penetration, volume, and any sources specific to each microenvironment. The definitions and properties of the microenvironments are crucial to an APEX run. The user may spend more time preparing this input file than on any other file. See Section 4.23 in UG1 for a detailed description of this file.

5.1.2. *Microenvironment Mapping* File

The *Microenvironment Mapping* file provides mapping of location codes for CHAD (see Table 5-1 below; from UG1, Section 4.18) to the user-defined APEX microenvironments and to the standard APEX location codes (shown in Table 4-3). The location specified by this file determines the choice of ambient air data, and the microenvironment determines the rules for modifying that ambient data (see Section 5.1.1). For more information on how APEX calculates air concentrations, see UG2, Section 8.

Users must assign each location code to the microenvironments defined in the *Microenvironment Descriptions* file by specifying the microenvironment number in the “APEX Microenvironment” column. All CHAD location codes must have associated microenvironment assignments or APEX will not successfully run. A zero in the “APEX Microenvironment” column will result in no exposure in that particular CHAD 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”).

See Section 4.18 in UG1 for a detailed description of this file.

Table 5-1. CHAD Location Codes

Code	Location Description	Code	Location 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

Code	Location Description	Code	Location Description
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
31121	Truck (pickup truck or van)	35610	School grounds
31122	Truck (not pickup truck or van)	35620	Public or park
31130	Motorcycle or moped	35700	Stadium or amphitheater

Code	Location Description	Code	Location Description
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

5.1.3. *Profile Functions* File

The *Profile Functions* input file, also known as the *Distributions* file, defines functions for variables associated with each simulated profile. There are four types of functions that can be defined, described below.

1. Functions for built-in APEX variables: These variables are predefined in APEX, whose values can be customized by functions defined in this file.

2. Functions for creating user-defined APEX conditional variables: These are also generic variables the user may define and use to calculate microenvironmental parameters. Up to eight of these variables can be defined in APEX.

3. Functions for creating user-defined APEX conditional variables that vary by region: These are generic variables the user may define and use to calculate microenvironmental parameters, but these conditional variables can vary by region and therefore may be evaluated differently for individuals who reside in different regions. Up to five of these functions may be defined.

4. Functions for creating user-defined APEX conditional variables that vary with ambient air quality: These are also generic variables the user may define and use to calculate microenvironmental parameters, but these conditional variables can vary by ambient air quality and therefore are recalculated during each time step. Up to five of these functions may be defined.

See UG1, Section 4.17 for more information.

5.1.4. Population Information

The default population, commuting, and employment input files provided with the APEX download are national in scope, at the Census tract-level, and reflect data for year 2010 (see the NationalDefaultDatabases folder from the APEX download in Section 3.1). The user can modify these files to reflect different years or spatial units.

The “Sector name” identifiers must match between all these files. Each *Population Data* file that is used in a model run must have a record for each sector listed in the *Population Sector Location* file to avoid fatal error. Sectors do not have to be in the same order in every population

file, but a single warning message will occur if APEX finds any number of differences. A “Sector name” is typically a code for a county or Census tract, which can contain leading zeroes; APEX reads these names as characters, so the leading zeroes are retained. If counties or tracts are being used in the “Sector name” field, then APEX will recognize the first five characters as the county identifier (if ***CountyList* = Y** in the *COF*) and the first 11 characters as the tract identifier (if ***TractList*** = **Y** in the *COF*). “Sector name” values can be arbitrary and up to 40 characters long. “Latitude” and “Longitude” should be provided in decimal degrees with at least 3 digits after the decimal point. See UG1, Section 4.3 for more information.

All *Population Data* input files must contain the same number of population groups, and all the group age limits (minima and maxima) must match as well or APEX will exit with a fatal error. The *Employment Probability*, *Prevalence*, and *Profile Factors* input files can have different age groups. See UG1, Section 4.8 for more information. Race can be described differently than the APEX descriptors of White, Black, Asian, Hispanic, Native American, or Other, but race labels must be consistent across the *Profile Summary* output file to avoid fatal errors. Sex descriptors can be “Female”, “Male”, or “All”.

5.1.5. Roadway Concentrations

When running with default settings, APEX will use ambient air concentrations to estimate all air concentrations in microenvironments. Optionally, the user may provide values of air concentrations to use specifically in “Road” and “Road Work” microenvironments. If the user wishes to specify a roadway air district, then “road” must appear within the district name in the *Air District Location* and *Air Quality Data* input files. Consequently, “road” cannot appear in the name of a regular air quality district. Then, APEX will use the air quality data from the “road” district closest to the home location when a profile is in a “Road” microenvironment, or closest to the work location when a profile is in a “Road Work” microenvironment. See UG1, Sections 4.2.2, 4.4, and 4.18 for more information.

5.1.6. Hourly Air Quality

For users who desire to use more complex air quality data, with distributions for each hour instead of single values, this section may be of interest. For typical air quality data requirements, see UG1, Section 4.5.

Typically, APEX assigns each person in a sector to the corresponding ambient air pollutant concentration that matches the sector’s air district. This means that all people in a single district will have the same outdoor air quality value. If users desire to model person-to-person variation in air quality within an air district, they should use the optional form of the *Air Quality Data* file. There, each person is assigned a randomly-sampled value from the appropriate hourly distribution. This may only be used when the APEX timestep is equal to 1 hour. This means that each record will list 24 hourly-average concentration values followed by a date. ***ModelAQVar*** must be set to **Y** in the *COF*, otherwise an APEX error will result. See UG1, Section 4.5.2 for more information.

5.1.7. Disease Prevalence

If users are interested in using APEX to model a subpopulation of persons with a particular disease or condition, ***Disease*** in the *COF* file can be set, which requires input of the *Prevalence* file. This will print a summary table for “ill” persons. The *Prevalence* file should contain probabilities for all age and sex cohorts from ages 0–99 regarding the prevalence of the disease in question as a function of sector. In the *Prevalence* file Gender, MinAge, and MaxAge should be binned as defined by the user. Values should be separated by one or more spaces. See UG1, Section 4.24 for more information. Note that the APEX model (i.e., source code, inputs, and outputs) might use "gender" rather than "sex" but they are intended to be synonymous. Future versions of APEX might replace "gender" with "sex.”

5.1.8. MET

It is not recommended that users change the *MET Mapping* file unless they have developed their own activity codes or defined their own occupation groups. Occupation groupings must match the occupations listed for activity code 10000.

It is also not generally recommended that users edit the distributions in the *MET Distribution* file, as these data were developed from extensive experimental data on human energy expenditures.

For more information, please see UG1, Sections 4.13 and 4.14.

5.2. Diary Assembly Options

There are different types of diary assembly options that may be selected by users of APEX based on keyword selection in the *COF*.

- ***LongitDiary***: if set to **Y**, a longitudinal diary assembly will be conducted based on the statistic in the *Diary Statistics* file.
- ***ClusterDiary***: if set to **Y**, the clustering algorithm will be conducted on the entire diary data and a record will be made of the outputs.

Utilization of the ***LongitDiary*** assembly options requires the *Diary Statistics* input file, while a *Cluster* and *Diary Transition* file will be required when ***ClusterDiary*** is used. The default in APEX is to use no diary assembly options, which results in a randomly selected new diary every day. For further information on diary assembly and clustering, please see UG1 Sections 2.4 and 4.21. An example *Cluster* and *Diary Transition* file is provided to users in the Miscellaneous folder from the APEX download in Section 3.1.

5.3. Multi-year Runs

An APEX simulation can be run for a time period covering multiple years. One noted limitation of APEX is that certain aspects of the personal profiles are held constant through time, though in

reality they change every year (e.g., age; also, ***AgeMax*** does not change over the simulation when conducting multi-year runs).

Users should also note that APEX internally refers to air quality districts by a sequential index assigned when the district-sector mapping is established. If users employ air quality monitoring data (i.e., instead of model output data), individual air quality monitors may have collected data over different time periods over the course of several years. A series of APEX runs at a single location over this course of several years would result in a different mapping of air quality monitors to air district numbers, depending on the availability of the data at a monitor for the specific period of time being modeled in each simulation (e.g., district #1 actually refers to two different air quality monitors between the first and second simulations). In this situation, users can prepare an *Air Quality Data* input file with complete data for all air quality districts for all years being modeled. This will prevent the mappings from changing between the different runs over the time period of the separate simulations.

5.4. Rollback Runs

Rollback runs are used to estimate exposure in hypothetical scenarios where ambient air quality data is adjusted before exposure calculations occur. This option allows users to determine exposure in hypothetical scenarios where ambient concentrations have been uniformly reduced by various measures.

As discussed in Section 3.2.2, this option may be selected in the *COF* file by setting the ***Rollback*** variable to **Y**. Users must also specify values for ***RBTarget*** (the rollback target concentration), ***RBBackgnd*** (an optional parameter for rollback background concentration, where the background is the part of the air quality unaffected by rollback controls), and ***RBMax*** (rollback maximum concentration) keywords in the *COF*. These values are used to calculate the required rollback factor RBFactor:

$$RBFactor = \frac{\boldsymbol{RBTarget - RBBackgnd}}{\boldsymbol{RBMax - RBBackgnd}}$$

Then, whenever the ambient concentration “Conc” exceeds ***RBBackgnd***, it is adjusted to:

$$Conc_{adj} = \boldsymbol{RbBackgnd} + RBFactor \times (Conc - \boldsymbol{RBBackgnd})$$

There is no adjustment when “Conc” is less than or equal to ***RBBackgnd***.

5.5. Multiple Pollutants

Users in APEX may wish to simulate population exposures to multiple pollutants. Co-exposures are well documented in reality, and APEX is able to assess these exposures in its simulations. It can model simultaneous exposure to any number of pollutants as long as users are able to provide the necessary input air quality data and pollutant parameters. It should be noted, however, that the pollutants are assumed to be present in the environment independently (i.e., no chemical reactions between pollutants are modeled in APEX).

APEX requires all pollutants to use the same air district information. Air quality data are required in all districts for all pollutants. If using roadway air quality mapping, it can be used on some pollutants and not others in the same run. Separate *Air Quality Data* files must be prepared for each pollutant in the simulation. More information on formatting these files can be found in the UG1, Section 4.5.

When conducting a multipollutant run, multiple files must be edited accordingly to account for the increase in pollutants. The *Microenvironment Descriptions* and *Microenvironment Mapping* files will typically need to be modified to reflect multiple pollutants (due to the differing behaviors of pollutants in specific microenvironments; see Sections 4.18 and 4.23 of UG1). While the *Microenvironment Descriptions* file explicitly contains the pollutant number on each factor (so these factors may vary by pollutant), the *Microenvironment Mapping* file requires a single set of microenvironments to be used for all pollutants. Therefore, a multipollutant run should use a set of microenvironments that provide sufficient detail for all the pollutants being modeled.

Additionally, the *COF* must be updated when multiple pollutants are simulated. This includes updating pollutant-specific parameters and table levels which each must immediately follow the line with their corresponding ***Pollutant*** keyword. Several *COF* keywords are pollutant-specific, including ***Pollutant***, ***InputUnits***, ***OutputUnits***, ***#Sources***, ***PPMFactor***, ***DoDose***, ***Size***, ***Density***, ***AlterThresh***, ***RoadWay***, and ***RoadLast***. In addition, the "Pollutant Parameters" section of the *COF* should be edited to specify the levels of each of the parameters used in the creation of the *Output Tables*, per pollutant, with table specifications coming after the corresponding keyword. These keywords include ***Percentiles***, ***DAvgExp***, ***DM1HExp***, ***DM8HExp***, ***DMTSExp***, ***SAvgExp***, ***TimeExp***, ***TSExp***, ***DAvgDose***, ***DM1HDose***, ***DM8HDose***, ***DMEHDose***, ***DMTSDose***, ***H_EHDose***, ***SAvgDose***, ***TimeDose***, ***TSDose***, ***TSMulti***, ***ResponseVar***, and ***ResponseProb***. Items should be comma delimited where appropriate (see Table 3-2). The *Microenvironmental Summary*, *Microenvironmental Results*, and *Output Tables* files are pollutant-specific, meaning one of each of these files will be created for each pollutant. However, only one file name for each type of file has to be defined in the *COF*—output file names for each pollutant are constructed by appending the pollutant name (as defined using the *COF* ***Pollutant*** keyword) to the end of the base file name. For more information and details regarding setting up the *COF* appropriately for multiple pollutants, see Section 4.2 of UG1.

6. Troubleshooting Commonly Encountered Errors

This section provides an enumeration of errors that users may encounter when attempting to run APEX. The list below is by no means comprehensive; however it includes some commonly occurring errors and reflects the general strategy for troubleshooting issues as they arise in an APEX simulation.

When a mistake is encountered in an aspect of an APEX run, the Fortran source code is no longer able to proceed in processing the code in tandem with the user specifications. As it would be difficult for APEX users to elucidate the source of the issue based on Fortran errors alone, a set of error messages has been written into APEX to alert users that something went wrong with the processing and to try and provide clues as to the possible reason behind the error. Warnings to users have also been written into the APEX code. Unlike errors which will cause APEX to stop processing and not complete the simulation, warnings will not cause APEX to stop processing but should be taken as an indication that an aspect of the simulation may be incorrect.

Errors in APEX are numbered on the basis of the procedure of the code in which the error occurred (i.e., Error # 2 in procedure “ReadParameters” is different from Error # 2 in procedure “ReadSiteList”). In the list of errors enumerated below, the procedure in which the error occurs, the error number, the text displayed to the user after the error number, and a brief discussion of the possible reason and fix are provided. Users should note that for some of the errors presented here, only a possible reasoning is provided, and different errors could produce the same error message. If the proposed possible solution to an error does not work, users should consult the relevant sections of this document as well as UG1 and UG2 for additional help, taking into account the information provided in the error message.

In Procedure: ReadParameters
Error number: 1
Text from error: Control file cannot be read
Cause and possible fix:

The name of the *Control Options* file as specified in the command prompt when trying to run APEX is incorrect. Ensure that the name of the *Control Options* file in the command prompt matches that of the actual name of the file (and that the file is in the same location as where APEX is being run, unless the full file paths are being used).

In Procedure: ReadParameters
In Procedure: ManageFiles
Error number: 112 [one of many possible error numbers]
Text from error: Districts input file [or another input file] does not exist
Cause and possible fix:

This error is being caused by the fact that APEX is not able to find the *Air District Location* input file, either because the file path is incorrect or the file is not in the specified location. A similar error will occur if APEX is not able to locate a different input file (e.g., if the *Air Quality Data*

input file is missing, the error number will be 117 in the ReadParameter and ManageFiles procedures). Ensure that the directory paths to each of the files are correct and that the files themselves are in their specified directories.

In Procedure: ReadParameters
In Procedure: CheckParameters
Error number: 37
Text from error: Bad micro # in MResMicros
Cause and possible fix:

The numbers supplied in the ***MResMicros*** parameter do not match available microenvironments described in the *Microenvironment Description* and *Microenvironment Mapping* input files. For example, this error could occur if the user has entered "1,2,3,6,7,8,10" as the list of microenvironments to have data written to the *Microenvironmental Results* file, but the user has only defined 5 microenvironments in the input files. Either modify the numbers in ***MResMicros*** or supply additional microenvironment information in the *Microenvironment Description* and *Microenvironment Mapping* input files.

In Procedure: ReadAirQuality
Error number: 3
Text from error: Missing or negative values in air quality data
Cause and possible fix:

There were missing and/or negative values in the air quality data. Review the *Air Quality Data* input file to ensure that there are air quality data for each hour at each air quality monitoring site, that the monitoring sites will fall within the ***CityRadius***, and that the ***AirRadius*** (or radii) will result in an overlap with sectors of interest.

In Procedure: ReadSiteLists
Error number: 3
Text from error: Unknown error
Cause and possible fix:

This error message can be caused by several different issues. One possible cause is the specification of the incorrect date range on the *Meteorology Zone Location* input file. Users should ensure that the date range in the *Meteorology Zone Location* file matches that in the *Meteorology Data* file, and that this date range will also encompass the date range defined by the ***Start_date*** and ***End_date*** in the *Control Options* file.

In Procedure: ReadMeteorologyData
Error number: 4
Text from error: Missing meteorology data
Cause and possible fix:

This error is caused by the fact that the *Meteorology Data* input file is missing data. This can be caused by a mismatch between the names of the meteorology zones. The names of the meteorology zones outlined in the first column of the *Meteorology Zone Location* file must match exactly the names specified at the beginning of each section in the *Meteorology Data* input file (e.g., "Name = [name of meteorology zone]"). Also note that, as in the *Control Options* file, only

spaces can be used to separate the “Name” identifier, equals sign, and the name of the meteorology zone in the *Meteorology Data* input file. Including a tab as a separator could cause APEX to not recognize the input text. Ensure that the names of the meteorology zones match and that there are not tabs being used as separators.

Text from warning: ReadProfileFunctions warning - Region does not have an associated sector.
Cause and possible fix:

This warning was issued due to the fact that one of the sectors to which was assigned a probability defined in the *Profile Functions* input file was not used. While no change to any input files is required, it is good practice to determine which specific function this warning occurred in based on the associated text in the warning, and subset the sectors that are assigned probabilities for this function in the *Profile Functions* file to those final sectors that are analyzed (a full analyzed list of sectors is written to the *Sites* output file).

Text from warning: Unrecognized info at parameters file data line # [many possible line numbers].
Cause and possible fix:

This warning means that a parameter name (either an input parameter or variable name to which an input or output file path is attributed) is unrecognized at the specified line number in the *COF*, where the line number is that in the file after all blank and comment lines (!) have been removed. APEX expects to encounter the names of specific variables and parameters on the *Control Options* file (e.g., *Seed* file, ***#profiles***, ***CityRadius***, etc.). When it encounters the name of a parameter or variable that it is not coded to anticipate, APEX only warns the user that it does not recognize this text as an expected name of a parameter or variable. This can also occur if an expected parameter or variable name was separated from the adjacent equals sign by a tab instead of a space (or several spaces). If the parameter or variable that was not recognized was actually the name of a required parameter entered incorrectly into the control file (e.g., “#profile” instead of “#profiles”) then subsequent to the warning issued by APEX an error message will appear as APEX was not able to read in the required parameter. Whether the warning message was for a required parameter or not, users should investigate the cause of the warning and modify the *Control Options* file as necessary.

In Procedure: ReadMeteorologyData
Error number: 4
Text from error: Missing meteorology data
Cause and possible fix:

This error may occur if there are tabs in the meteorological data input file. If so, replaces these tabs with spaces to fix this error.

In Procedure: CompositeDiary
Error number: 1
Text from error: No events in sequence, check cluster file
Cause and possible fix:

This error typically results from typos in the events file when using a user-generated events file.

Text from warning: Out of memory: array allocation failed.
Cause and possible fix:

If you receive this error it is because one of the large arrays is requesting more memory than is available. You can try reducing the number of air quality districts if there are more than 1,000. Send an email describing this problem to the APEX contact person.

In Procedure: ReadParameters
Error number: 7
Text from error: Undefined pollutant in AQ file keyword
Cause and possible fix:

The pollutant name in the AQ file keyword needs to be the same as a pollutant defined later in the COF.

In Procedure: ReadSiteLists
In Procedure: JulianDay
Error number: 2
Text from error: Month not between 1 and 12 inclusive
Cause and possible fix:

The format of dates in the meteorological locations (zones) file or the air quality locations (districts) file is incorrect. It should be of the form YYYYMMDD.

In Procedure: ReadAirQuality
Error number: 3
Text from error: Problem reading air quality data
Cause and possible fix:

This is typically due to non-numeric characters in the air quality data file where there should be numeric data (e.g., a code for missing data).

In Procedure: DiaryProbabilities
Error number: 1
Text from error: At least one diary pool was empty
Cause and possible fix:

The diary pools need to be increased in size, This can be done in the profile functions file (see pages 86-87 in UG1 and try reducing the number of bins) or in the COF (see Diary Selection Parameters on pages 43-44 in UG1 to relax the restrictions on the pools)

In Procedure: ReadMicroData
Error number: 5
Text from error: Problem with line number 96
Cause and possible fix:

Too few distributions for microparameter. Check line 96 in the microenvironment descriptions input file.
In Procedure: ReadParameters

In Procedure: OpenOutput
Error number: 40
Text from error: Unknown error
Cause and possible fix:

One or more pathnames for output files in the *COF* may be incorrect.

7. References

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Appendix A. Post-processing Scripts

A.1 SAS Scripts

Below are examples of SAS code that can be used to read most of the APEX output files (all except for the *Output Tables* file, which contains formatted tables). The precise statement used to read in the data will depend on which variables are selected in the *COF* to be written to the file. Table A-1 shows how much the output file sizes can vary depending on how many variables are selected in the *COF* to be written to the files. The examples here give the *COF* file output options used that correspond to the example run available with the APEX download. In practice, the user specifies the variables to be written to the output files in the *COF* and modifies the example code appropriately after looking at the output file.

For example, the example code for reading the *Profile Summary* file assumes that the *COF* specifies

```
PSumList = AVGEXP MAXEXP
```

in which case the first few records of the *Profile Summary* file are as shown below.

```
 APEX Personal Summary File
 APEX Version 5.0   Run Date = 20170110  Time = 131125
 Location    = Los Angeles Area
 Scenario    = Los Angeles (CSA 348), Jan-Dec 2010 Base case, 2010 pop
 Simulation  = cof_CSA348SbaseY2010T_E6540_REA1concs_newEXE.txt
 Pollutant   = O3
 Air Quality = ! 2010 base ozone air quality data for CSA 348

P HSect WSect HDis WDis Zone Age Sex Race Empl Height Weight AvgExp_O3
MaxExp_O3
 1  1553  1553   5   5   4  12 F   All N 63.195  68.870 8.244E-03 8.500E-02
 2  2781  2781  16  16   4   7 F   All N 56.103  56.492 8.879E-03 1.033E-01
 3  1181  1181   1   1   4  13 M   All N 64.127 108.816 6.924E-03 1.040E-01
```

If the user wants to include additional information on whether or not profiles have air conditioning in their cars or homes or stoves in their homes, the *COF* will specify the line that follows.

```
PSumList = AVGEXP MAXEXP ACCAR ACHOM STOVE
```

The first few records of the *Profile Summary* file are then as shown below.

```
 APEX Personal Summary File
 APEX Version 5.0   Run Date = 20170110  Time = 132648
 Location    = Los Angeles Area
 Scenario    = Los Angeles (CSA 348), Jan-Dec 2010 Base case, 2010 pop
 Simulation  = cof_CSA348SbaseY2010T_E6540_REA1concs_newEXE.txt
 Pollutant   = O3
```

```
 Air Quality = ! 2010 base ozone air quality data for CSA 348

P HSect WSect HDis WDis Zone Age Sex Race Empl Height Weight ACCar ACHom
Stove AvgExp_O3 MaxExp_O3
 1  1553  1553   5   5   4  12 F   All N 63.195  68.870 Y 3 X 8.244E-03
8.500E-02
 2  2781  2781  16  16   4   7 F   All N 56.103  56.492 N 2 X 8.879E-03
1.033E-01
 3  1181  1181   1   1   4  13 M   All N 64.127 108.816 Y 2 X 6.924E-03
1.040E-01
```

The SAS input statement would be modified to be as shown below.

```
input P HSect WSect HDis WDis Zone Age Sex $40 Race $44
      Empl $48 Height Weight ACCar $65 ACHom 67 Stove $69
      AvgExp_O3 MaxExp_O3;
```

Table A-1. The Smallest and Largest Output File Sizes (Depending on *COF* Options) for 1000 Profiles, 365 Days, Hourly Timestep, 28 Microenvironments, and 1 Pollutant

Output File	Control File Keyword	Smallest Size (KB)	Largest Size (KB)
Log File	LOG	82	82
Profile Summary (Persons) File[a]	PERSONS	64	423
Output Tables File	TABLES	2	512
Sites File	SITE	933	933
Hourly File[a,b]	HOURLY	153,985	6,937,853
Daily File[a]	DAILY	4,635	43,131
Events File[a]	EVENTS	890,749	2,411,874
Microenvironmental Summary File	MICROSUM	1,332	1,332
Microenvironmental Results File[a,b,c,d]	MICRORES	300,235	40,172,911

[a] These file sizes are proportional to the number of profiles simulated.
[b] These files are also proportional to the number of days simulated.
[c] These files are also proportional to the number of timesteps per day.
[d] The size of this file is also proportional to the number of microenvironments specified by ***MResMicros*** in the *COF*. This size assumes that ***MresHome*=Y** in the *COF*; otherwise, the file size is multiplied by the number of distinct locations in the *Microenvironment Mapping* file.

A.1.1 *Sites* File

```
/* ReadApexSitesFile.sas

   Reads the APEX sites output file.

INPUT:  sites.txt
```

```
OUTPUT: sasfiles.sites
*/
/*options sets the line size to 120 characters and page size to 60 lines
Libname locates the SAS files and creates a library in the SAS environment
Title statement creates a title for the output*/
options ls=120 ps=60;
libname sasfiles "C:\APEXexample\sasfiles";

title "Reading Apex Sites file    %sysfunc(date(),worddate.)";


***  READ THE SITES FILE;
/*Data statement creates a data file in the library called sasfiles
Length option returns the length of the listed variables
Infile statement locates the raw data file sites.txt
Input statement dictates which variables to read in and the column location*/

data sasfiles.sites;
   length SectorName $40 DistrictName $40 ZoneName $40;
   length tract $11;
   infile "C:\APEXexample\Output\sites_out.txt" firstobs=10 lrecl=500
         stopover;
   input SectorNum  SectorLat   SectorLon    @35 SectorName   $40.
         DistrictNum DistrictDistance DistrictLat DistrictLon @120
         DistrictName $40. ZoneNum   ZoneDistance   ZoneLat  ZoneLon  @205
         ZoneName     $40.;
   tract = trim(SectorName);
   /*trims the character strings of blanks in the sector name*/
run;
title2 "The Sites file (the first 12 sectors)";
proc print data=sasfiles.sites(obs=12);
/*proc print prints out the a list of variables and any labels associated
with it for the first 12 observations*/
run;
```

A.1.2 *Profile Summary* File

```
/* ReadApexPsumFile.sas

   Reads the APEX psum, daily, hourly, and sites output files.

INPUT:  psum.txt, sasfiles.sites

OUTPUT: sasfiles.psum    Variables:
   profile HSectorNum WSectorNum HDistrictNum WDistrictNum Zone Age male Race
employed Height Weight ACHom BSA ECF MetMax VO2Max MOXD PAI RecT RMR VEInter
VESlope VEResid BMI FEVU NumDiaries AvgExp_POLL1 MaxExp_POLL1
*/


/* options sets the line size to 120 characters and page size to 60 lines
Libname locates the SAS files and creates a library in the SAS environment
```

```
Title statement creates a title for the output*/
options ls=120 ps=60;
libname sasfiles "C:\APEXexample\sasfiles";

title "Reading Apex Psum file      %sysfunc(date(),worddate.)";

/* The personal summary (Psum) file in APEX contains a user-specified
list of variables. This is controlled by one or more lines with the keyword
“PSumList” on the control file.

Some examples of PSumList options:
PSumList    = AVGEXP MAXEXP
PSumList    = #DIARIES ACHOM ACCAR DISEASE PILOT STOVE EVENTS BLOODVOL BSA
PSumList    = ECF DIFFUS ENDGN1 ENDGN2 HEMOGLOBIN METMAX VO2MAX MOXD PAI
PSumList    = RECTIME RMR VEINTER VERESID VESLOPE
PSumList    = B1 B2 B3 B4 B5 B6 B7 VARU FEVSLP FEVINT BMI FEVU
2 pollutants
 length Gender Empl ACHom $1 Race $5 poptype $2 Disease Stove Pilot ACCar $1;
 input profile HSectorNum WSectorNum HDistrictNum WDistrictNum Zone Age
       Gender $40 Race $44 Empl $48 Height 49-55 Weight 56-64 ACCar $65
       ACHom $67 Disease $69 Pilot $71 Stove $73 NumEvents 74-78
       BloodVol 79-87 BSA 88-92 ECF 93-99 Diffus 100-106 Endgn1 107-115
       Endgn2 116-124 Hemoglob 125-131 MetMax 132-138 VO2Max 139-145
       MOXD 146-152 PAI 153-157 RecT 158-164 RMR 165-170 VEInter 171-179
       VESlope 180-188 VEResid 189-197 BMI 198-206 Beta1 207-215 Beta2
       216-224 Beta3 225-233 Beta4 234-242 Beta5 243-251 Beta6 252-260
       Beta7 261-269 VarU 270-278 FEVSLP 279-287 FEVINT 288-296
       NumDiaries 297-300 AvgExp_POLL1 301-310 MaxExp_POLL1 311-320
       AvgExp_POLL2 321-330 MaxExp_POLL2 331-340;

PSumList    = AVGEXP MAXEXP #DIARIES BSA BMI ECF METMAX VO2MAX MOXD PAI
PSumList    = RECTIME RMR VEINTER VERESID VESLOPE ACHOM FEVU
1 pollutant
length Gender Empl ACHom $1 Race $5;
input profile HSectorNum WSectorNum HDistrictNum WDistrictNum Zone Age
      Gender $40 Race $44 Empl $48 Height 49-55 Weight 56-64 ACHom $65
      BSA 66-70 ECF 71-77 MetMax 78-84 VO2Max 85-91 MOXD 92-98 PAI 99-103
      RecT 104-110 RMR 111-116 VEInter 117-125 VESlope 126-134
      VEResid 135-143 BMI 144-152 FEVU 153-161 NumDiaries 162-165
      AvgExp_POLL1 166-175 MaxExp_POLL1 176-185;
*/


/*Data statement creates a data file in the library called sasfiles
Infile statement locates the raw data file sites.txt */

data psum;

   infile "C:\APEXexample\Output\personal_summary_out.txt" firstobs=10
     lrecl=500 missover;
/*

/* PSumList    = MAXEXP
```

```
   1 pollutant          */

/* Length option returns the length of the listed variables
Input statement dictates which variables to read in and its corresponding
column*/

   length Gender Empl $1 Race $5;
   input profile HSectorNum WSectorNum HDistrictNum WDistrictNum Zone Age
         Gender $40 Race $42-46 Empl $48 Height 49-55 Weight 56-63
         MaxExp_POLL1 64-73;

run;

***  MERGE IN HOME AND WORK DISTRICT IDS FROM THE SITES FILE;
* Note that not all tracts necessarily have profiles;
/*Data statement creates the data file, Hsitesxref, in the library called
work
Set statement informs SAS where to get the data for the permanent file it is
creating
Rename option renames the SectorNum variable as HSectorNum
Keep specifies which variables to keep in the dataset*/
data Hsitesxref;
   set sasfiles.sites(rename=(SectorNum=HSectorNum));
   keep HSectorNum tract;
run;

/*Sort statement sorts the data in ascending order by the HSectorNum variable
Data=psum option has SAS pull the psum dsataset and sort it in ascending
order by the HsectorNum variable
Data statement creates a new dataset called psum1 in the temporary “work”
folder
Merge option merges the two active datasets psum and Hsitesxref to create a
new dataset called psum1
IN= creates a new variable in1. Variable has value of 1 when the observation
is read from the psum dataset otherwise it is a value of 0.
By option indicates that merging will occur using the HSectorNum variable
If statement checks the value of in1 to see if the dataset psum contributed
to the data in the current observation*/

proc sort; by HSectorNum; run;
proc sort data=psum; by HSectorNum; run;
data psum1;
   merge psum(in=in1) Hsitesxref;
   by HSectorNum;
   if in1;
run;

/*Data statement creates a datafile called psum
Set statement directs SAS to where to get the dataset, which is in a work
library and called psum1
Title2 prints out the text in the quotations as the title for output
Proc Contents prints out all the variables in the psum dataset
```

```
Proc Means statement produces the means and confidence intervals of all
variables in the psum dataset
Proc Print statement prints out a list of the variables and any labels
associated with it for the first 10 observations (obs=10)*/

data sasfiles.psum; set psum1; run;

title2 "APEX person-level summary data (psum)";
proc contents data=sasfiles.psum; run;
proc means data=sasfiles.psum; run;
proc print data=sasfiles.psum(obs=10); run;
```

A.1.3 *Hourly* File

```
/* ReadApexHourlyFile.sas

   Reads the APEX hourly output file.

INPUT:  hourly.txt

OUTPUT: sasfiles.hourly    Variables:
 profile time (hour of simulation) hour (of day) day (of simulation) sdate
(SAS date) Ve EVR MET pctdFEV1max FEV_E1 FEV_E2 54-61 Amb_POLL1 62-71
Exp_POLL1
OR      sasfiles.hourly_wide
*/

/*Options sets the line size to 120 characters and page size to 60 lines
Libname locates the SAS files and creates a library in the SAS environment*/

options ls=120 ps=60;
libname sasfiles "C:\APEXexample\sasfiles";


/*%Let initiates the macro STARTDAYM1 where the program uses the Julian
calendar start date, with Jan 1st as the beginning of the program valued as 0
%Let initiates the macro in which the YEAR variable will be set to 2010
Title statement produces a title printing out the start date for the
simulation*/

***  SET THE JULIAN DATE (minus one) FOR THE START OF THE SIMULATION;
%LET STARTDAYM1 = 0;  /* the Julian start date minus 1.  0 for January 1
start date. */
%LET YEAR = 2010;

title "Reading Apex Hourly file  STARTDAYM1 = &STARTDAYM1
%sysfunc(date(),worddate.)";


***  READ THE APEX HOURLY OUTPUT FILE;
/***  WIDE FORMAT;
```

```
data sasfiles.hourly_wide;
   format sdate mmddyy8.;
   array ExpHr_POLL ExpHr_POLL1-ExpHr_POLL24;
   array AmbHr_POLL AmbHr_POLL1-AmbHr_POLL24;
   retain ExpHr_POLL1-ExpHr_POLL24 AmbHr_POLL1-AmbHr_POLL24;
   infile "C:\APEXexample\Output\hourly.txt" firstobs=10 lrecl=500 missover;
* firstobs = 9 + #polls;
   input P time Ve EVR MET pctdFEV1max FEV_E1 FEV_E2 54-61 Amb_POLL 62-71
Exp_POLL 72-81;
   hour = mod(time-1,24) + 1;
   day = int((time-1+0.01)/24) + 1;
   sdate = datejul(1000*&YEAR + day + &STARTDAYM1);
   ExpHr_POLL[hour] = Exp_POLL;
   AmbHr_POLL[hour] = Amb_POLL;
   if hour=24 then output;
   keep Profile sdate AmbHr_POLL1-AmbHr_POLL24 ExpHr_POLL1-ExpHr_POLL24;
run;
*/


***  READ THE APEX HOURLY OUTPUT FILE and save in alternative (unwound)
format;

/*DATA creates the data set, hourly, in the library called sasfiles
FORMAT statement produces the SAS date as month, day, year for up to 8
characters
INFILE statement specifies the raw data file hourly.txt to read into the SAS
environment
FIRSTOBS tells SAS to start the input of the file with observation #10
LRECL specifies the logical record length in bytes
MISSOVER prevents the input statement from reading in a new input record if
it does not contain a value, for each blank value it will be set to missing
INPUT statement lists each variable name and its corresponding column
position
HOUR value is calculated using the MOD function, which returns the remainder
of the division of the first element by the second element.
DAY variable is calculated using INT function which returns the integer value
SDATE is equal to the Julian date*/

data sasfiles.hourly;
   format sdate mmddyy8.;
   infile "C:\APEXexample\Output\hourly_out.txt" firstobs=10 lrecl=500
      missover;
   input Profile time mets exp1 exp2 exp3 exp4 exp5 amb Exp_POLL;
   hour = mod(time-1,24) + 1;
   day = int((time-1+0.01)/24) + 1;
   sdate = datejul(1000*&YEAR + day + &STARTDAYM1);
run;

/*TITLE2 is the printed in the output
PROC PRINT prints out the first 40 observations in the results*/

title2 "The hourly file (first 40 obs)";
```

```
proc print data=sasfiles.hourly(obs=40); run;
```

A.1.4 *Events* File

```
/* ReadApexEventsFile.sas

   Reads the APEX Events output file written per:
   EventsList = MET UMET VA VE EVR DEFICIT AMB HOMEAMB dFEV1 XFEV

   INPUT FILES:
      events.txt

   OUTPUT FILES:
      sasfiles.events    Variables:

      act         The activity code
      DayNum      The day number from start of the run
      Duration    The duration of this event in minutes
      Exp_&POLL   The exposure concentration during this event
      Amb_&POLL   The ambient concentration during this event
      HomeAmb_&POLL
      Hour        The hour (1 to 24)
      HWO         Home/work/other location code
      Micro       Microenvironment code (2-character, 0 to 12)
      P           The profile number
      sdate       The SAS date
      Seq         The sequence number for the event
      UMET MET VA VE Deficit EVR dFEV1_pct XFEV
      Dose_O3 EndDose_O3 (ozone only)
*/

/* options sets the line size to 120 characters and page size to 60 lines
Libname locates the SAS files and creates a library in the SAS environment
Title statement creates a title for the output*/

options ls=160 ps=60;
libname sasfiles "C:\APEXexample\sasfiles";
title "Reading APEX Events Output File    %sysfunc(date(),worddate.)";

/*DATA statement creates a data file named events in the library called
sasfiles
LENGTH option returns the length of the listed variables
INFILE statement locates the raw data file events.txt
INPUT statement dictates which variables to read in and its corresponding
column*/

data sasfiles.events;

   infile "C:\APEXexample\Output\events_out.txt" firstobs=10;

   input Profile Seq DayNum Year Month Day Hour Duration act
         Micro homework exp;
```

```
/*FORMAT statement formats the sas date to an eight character limit
SDATE variable is equal to the mdy variable
DROP excludes the month day and year variables from the output*/
   format sdate mmddyy8.;
   sdate=mdy(month,day,year);
   drop month day year;
run;

/*PROC CONTENTS lists all the variables in the dataset called events
TITLE2 produces a title that appears in the output of analysis
PROC PRINT produces an output of the first 40 observations with the first
TITLE statement */

proc contents data=sasfiles.events; run;
title2 "The first 40 events for the first profile";
proc print data=sasfiles.events(obs=40); run; title;
```

A.1.5 *Timestep* File

Note: The example APEX run provided with this document does not produce a timestep file, because it uses the default timestep of one hour (hence, the hourly output file contains the same information as the timestep file would).

```
/* Read5MinuteTimestepFile.sas

   Reads the APEX 5-minute timestep output file, sets time variables,
   and writes out the file in SAS format;

INPUT:  timestep.txt  The APEX timestep output file.

OUTPUT: sasfiles.timestep   (profile Day Hour Period Amb_&POLL Exp_&POLL EVR)

*/

/*LIBNAME locates the SAS files and creates a library in the SAS environment
%LET signals the creation of a macro, with POLL as the macro variable and SO2
values assigned to the variables
DATA statement creates a data file called timestep in the SASFILES folder
created in the SAS system
LENGTH option returns the length of the listed variables
INFILE statement locates the raw data file timestep.txt
FIRSTOBS tells SAS to start the input of the file on your computer with
observation #10
LRECL specifies the logical record length in bytes
MISSOVER prevents the input statement from reading in a new input record if
it does not contain a value, for each blank value it will be set to missing
INPUT statement dictates which variables to read in and its corresponding
column
IF option has period value is 0 then change it to 12
KEEP option keeps the variables listed */
```

```
libname sasfiles "C:\APEX\sasfiles";
%LET POLL = SO2;

***  READ THE APEX TIMESTEP OUTPUT FILE;
/* infile should be the same location where your text file is, and should
have the same name as your timestep text file.*/
data sasfiles.timestep;
   length Day Hour Period 3 profile Amb_&POLL Exp_&POLL EVR 4;
   infile "C:\APEXSO2\TractsOut\Output\timestep.txt" firstobs=10 lrecl=500
missover;
   input profile Hr Timestep EVR Amb_&POLL Exp_&POLL;
   Period = mod(timestep,12);
   if Period = 0 then Period = 12;
   Day = int((Hr-0.1)/24) + 1;
   Hour = Hr - 24 * (Day - 1);
   keep profile Day Hour Period Amb_&POLL Exp_&POLL EVR;
run;
```

A.1.6 *Daily* File

```
/* ReadApexDailyFile.sas

   Reads the APEX daily output file.

INPUT:  daily.txt

OUTPUT: sasfiles.daily   Variables:
  profile Day (of simulation) CHADID PAI KeyVar pctdFEV1max Max1Exp_&POLL
Max8Exp_&POLL
*/

/* OPTIONS sets the line size to 120 characters and page size to 60 lines
LIBNAME locates the SAS files and creates a library in the SAS environment
%LET signals the creation of a macro. Creates variable Poll and assigns it
the value Ozone
&LET calls in the macro STARTDAYM1 and assigns a Julian start date of 0
%LET calls in the macro YEAR and sets it to 2010
TITLE produces an title for the output*/


options ls=120 ps=60;
libname sasfiles "C:\APEXexample\sasfiles";
%LET POLL = Ozone;

***  SET THE JULIAN DATE (minus one) FOR THE START OF THE SIMULATION;
%LET STARTDAYM1 = 0;  /* the Julian start date minus 1.  0 for January 1
start date. */
%LET YEAR = 2010;
```

```
title "Reading Apex Daily file  STARTDAYM1 = &STARTDAYM1
%sysfunc(date(),worddate.)";


/*DATA statement creates daily data set in the sasfiles library
FORMAT statement produces the SAS date as month, day, year for up to 8
characters
LENGTH statement sets the length of the CHADID character variable to 9
INFILE statement specifies the raw data file daily.txt to read into the SAS
environment
FIRSTOBS tells SAS to start the input of the file with observation #10
LRECL specifies the logical record length in bytes
STOPOVER statement uses the missing values as errors
INPUT statement lists each variable name and its corresponding column
position
SDATE specifies a SAS numeric expression that represents a Julina date as
yyyydd */

***  READ THE APEX DAILY OUTPUT FILE;
data sasfiles.daily;
   format sdate mmddyy8.;
   length CHADID $9;
   infile "C:\APEXexample\Output\daily_out.txt" firstobs=10 lrecl=500
stopover;
   input profile Day age dfev1max avg_&poll max_&poll;
run;
/*TITLE2 statement prints out the specified title for outputs
PROC PRINT prints out the first 12 observations from the sasfiles.daily
datafile*/

title2 "The daily file (first 12 obs)";
proc print data=sasfiles.daily(obs=12); run;
```

A.2 R Scripts

Below are examples of R code that can be used to read most of the APEX output files (all except for the *Output Tables* file, which contains formatted tables). The precise statement used to read in the data will depend on which variables are selected on the *COF* to be written to the file. The examples here give the *COF* output options used that correspond to the example run available with the APEX download.[1] In practice, the user specifies the variables to be written to the output files in the *COF* and modifies the example code appropriately after looking at the output file.

Unlike the SAS scripts, all columns in the text output file from APEX will be uploaded in R unless otherwise specified. Included in the script are two packages, plyr and dplyr, both by Hadley Wickham 2011 and 2016 respectively. Dplyr is a newer package and requires R to be at least version 3.1.2 to run. In addition, plry should be loaded before dplyr to ensure all functions will work properly.

Almost all the output files deal with dates, and R has a specific format for manipulation of dates. In the comments of the code, there are multiple explanations regarding how to import dates from the APEX output and how to change the dates to a more user-friendly format. This code does not have an export function, but users can write a line of code to specify their desired output.

Users should also note that the *Timestep* file will not be produced if users enter '24' as the value for ***TimestepsPerDay*** (resulting in hourly timestep results) in the *COF*. Otherwise, users can choose to output both the *Hourly* file and *Timestep* file.

References

Hadley Wickham (2011). The Split-Apply-Combine Strategy for Data Analysis. Journal of Statistical Software, 40(1), 1-29. URL: http://www.jstatsoft.org/v40/i01/

Hadley Wickham and Romain Francois (2016). dplyr: A Grammar of Data Manipulation. R package version 0.5.0. URL: https://CRAN.R-project.org/package=dplyr

```
##Set to where the text files from Apex were stored
setwd("~/APEX")
##these will be used in functions later on so download it. Please upload plyr
before dplyr. If you do not then some of the functions in these packages will
fail
require(plyr)
require(dplyr)
##this can be used to read in five different output files from apex
##these are the Sites_Out, Personal_Summary_Out, Hourly_Out, Events_Out,
Timestep, Daily_out
##all the files that are read in use the read table function
##the skip 8 means the info at the first 8 lines will not be read
##header is set to TRUE
```

```
##this will read the Sites_Out file
sites<-read.table("Sites_Out.txt", skip=8, comment.char     ="", header=TRUE)

##this name change allows the sites file to link up with the personal summary
output by linking home sectors
names(sites)[ names(sites) == "sector."] <- "HSect"

##this is the personal summary file, you will need to read the sites file and
use the renaming line to use the following code
personal<-read.table("Personal_Summary_Out.txt", skip=8, comment.char   ="",
header=TRUE)

##this merges psum and sites by home sector
##the sites file is added to get the exact location site
personal_sites<-merge(personal, sites, by = "HSect")
##orders the file in numeric order
personal_sites<-personal_sites[order(personal_sites$P),]

##this reads the Hourly_out file

Hourly_Out<-read.table("Hourly_Out.txt", skip=8, comment.char     ="",
header=TRUE)

Hourly_Out$ID<-rep(1:length(Hourly_Out$P),1)

Hourly_Out_time<-Hourly_Out[c("ID", "P", "Hour")]

Hourly_Out$P<-NULL
Hourly_Out$Hour<-NULL
##setting the initial date which you can change
dates<-"01/01/10"
##r needs to convert things into a date format like so
betterDates <- as.Date(dates,
                       format = "%m/%d/%y")

Hourly_Out_time$sdat<-betterDates
person_split<-split(Hourly_Out_time, f = Hourly_Out_time$P)
##this takes the hour for each person and converts it to days, date, and time
per day with hours 1-24
time_stamp<-function(person){
  ##to help recombine
  ID<-person$ID
  Person<-person$p
  hour<-person$Hour
  ##coverts into day
  day<-as.integer((hour-1)/24+1)
  day_hour<-hour-(24*(day-1))
  ##date
  sdat_pre<-person$sdat+day-1
  sdat<-format(sdat_pre, "%D")
  cbind(ID,  sdat,Person,hour, day, day_hour)
}
```

```
Hourly_Out_time<-ldply(lapply(person_split,time_stamp ),
stringsAsFactors=FALSE)
names(Hourly_Out_time)[ names(Hourly_Out_time) == ".id"] <- "Profile"
##sort is made false so that way the ID number match up in 1,2,3...
##r will sort lexicographically which means 1,10,11
Hourly_Out<-merge( Hourly_Out_time, Hourly_Out,by = "ID", sort=FALSE)

##this passes the class for to be numeric so it sorts correctly
Hourly_Out$Profile<-as.numeric(Hourly_Out$Profile)
Hourly_Out$ID<-as.numeric(Hourly_Out$ID)


##this reads the Events_out file

Events<-read.table("Events_Out.txt", skip=8, comment.char   ="", header=TRUE)

##creates a column that has the date set as date in R
Events$date<-as.Date(paste(Events$Year, "-", Events$Mn, "-",  Events$Dy,
sep=""))

##changes format to month ,date, year. In year it will display the full year.
However if you want it to be the 1900's
##change the 20%y to be 19%y
Events$date<-format(Events$date, "%m-%d-20%y")
##drops DY, Mn, and Year from Events Data frame
Events$Year<-NULL
Events$Mn<-NULL
Events$Dy<-NULL


##this reads the Timestep file
##this file is only produced if you do not employ a 1 hour timestep
##the example run in the APEX Intro Document will not produce this file
timestep<-read.table("timestep.txt", skip=8, comment.char="", header = TRUE)
##this uses the function sapply to pass the function of x/24+1
##this is then taken as an integer to get the Day number
timestep$day<-as.integer(sapply(timestep$Hour, function(x) (x/24+1)))
##this function is an if else clause
##if the timestep variable is above 0, it takes the timestep value and
subtracts the number of time steps that have occurred past hour one.
##this was done so that you get the 5 min window in each hour
##syntax has it when the first 5 min window is 1 and the last is 12
##in addition it produces an error if there is a value in temstep less than
zero, because all values should be above zero
timestep$Period<-ifelse(timestep$Timestep>0, (timestep$Timestep-
(timestep$Hour-1)*12),"error")
##removes timestep column
timestep$Timestep<-NULL


##this reads the Daily_out file
Daily<-read.table("Daily_out.txt", skip=8, comment.char="", header = TRUE)
```

```
##this is a wrapper function that does the following
##taking the start date, it is added to the day number, after that it is
reformatted to m/d/y notation
## this is applied to the entire Day column and
##then saved under a new column name
##if you want to change the start date, just change the numbers in ""
##this has to be in that format of m/d/y with the 20%y meaning that it is in
the 2000's. If it is in the 1900's
##you would change the 20%y to 19%y
Daily$sdate<-sapply(Daily$Day, function(x) format((x+as.Date("01/01/2010",
                                                    format =
"%m/%d/20%y")), "%m/%d/20%y"))
```