User's and Programmer's Manual

for the

Total Human Exposure Model (THEM)

Version 1.0

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ABSTRACT

The details of a Total Human Exposure Model (THEM) that calculates 24-hour exposure profiles using real human activity patterns and indoor air models derived from actual measurements of Respirable Suspended Particles (RSP) are described from both the user's and the programmer's perspectives. Included are descriptions of: (1) the mathematical basis for THEM, (2) the user interface, files, and options in THEM, (3) an example calculation for the San Francisco Bay Area, (4) the flow of the THEM program, (5) the subprograms and variables contained in the THEM source code, and (6) methods of adding custom subprograms to THEM. The source code for version 1.0 of the THEM software (included in an Appendix) was written in Microsoft™ Professional BASIC version 7.1 for implementation on IBM-compatible personal computers. [Currently, the model uses the California Activity Pattern (CAP) database obtained from the Air Resources Board. These data include diaries of over 1700 adults and children that contain coded information on microenvironments, which consist of locations and activities. The diary codes correspond to locations in factories, offices, restaurants and homes (room specific), and whether or not an individual is in the presence of a smoker. THEM determines RSP exposure by taking the microenvironmental information from the CAP data and assigning RSP levels for (1) Environmental Tobacco Smoke (ETS) and (2) ambient levels (from motor vehicles and wood smoke). For ambient data, actual hourly diurnal particulate measurements are obtained from a continuous monitoring instrument. THEM computes RSP exposures from ETS using validated models based on the mass balance equation. Source strengths, smoking rates, room air exchange rates, and room volumes are incorporated into the model by randomly sampling from actual distributions of data. An execution of THEM for 381 people on a 33 MHz 486 computer for both microenvironmental and ambient exposures took approximately 20 minutes.

PREFACE

This document is part of a series of Stanford University reports on the exposure of Californians to Environmental Tobacco Smoke (ETS) supported in part by the Tobacco Related Disease Research Program (TRDRP), Grant No. 2RT0274. The previous reports consisted of detailed analyses of the California Activity Pattern (CAP) Survey conducted by the California Air Resources Board (CARB). This report is a user's and programmer's manual that describes the Total Human Exposure Model (THEM), which was developed, in part, to study the proportion that ETS contributes to overall exposure to Respirable Suspended Particles (RSP). THEM is part of a new class of human activity pattern-exposure models that integrate activity pattern data and measurements of pollutant concentration for different sources and in different locations to produce frequency distributions of exposure for entire populations.

INTRODUCTION

The Total Human Exposure Model (THEM) described in this user's and programmer's manual was developed at Stanford University to compute the frequency distribution of human exposures to Respirable Suspended Particles (RSP) from Environmental Tobacco Smoke (ETS) and ambient sources for the populations of California. The California Activity Pattern (CAP)[1,2,3,4] data from the California Air Resources Board (ARB) was used to supply diary data and codes for the locations and the presence of a smoker. Microenvironmental concentrations of RSP were generated using a Sequential Cigarette Exposure Model (SCEM)[5] also developed at Stanford University and validated in field experiments. Parameter inputs for SCEM were either estimated by the authors or came from actual data on air exchange rates[6] and house footage[7]. Other estimates of microenvironmental concentrations were based on field studies conducted at Stanford University as part of the Califronia Environmental Tobacco Smoke Field Survey (CETFS) supported by the Tobacco Related Disease Research Program (TRDRP). Ambient concentrations came from the air monitoring network operated by the Bay Area Air Quality Managment District (BAAQMD)[8]. An example exposure calculation from THEM for the subpopulation of the San Francisco Bay Area is given in Part 7 of Section IV of this manual. The basis for much of THEM is theSimulation of Human Acitivity and Pollutant Exposure (SHAPE) Model.[9, 10, 11] A complete description of the THEM methodology is available in another paper[12]. Although THEM has been designed and applied primarily to air pollutants, the theoretical framework in THEM can be extended in the future to dermal exposure and to other exposure media.

Although THEM was first written for a specific pollutant (RSP) with microenvironmental and activity pattern data for a specific population (California), it was designed to be expandable to compute exposures for any population and any pollutant. The modular design allows for both the facile addition of procedures containing any number of mass balance or chemical microenvironmental models, and the simple alteration of the control structure in a single module that determines what models are incorporated into a THEM calculation. THEM reads external text files containing activity pattern data, ambient data, activity and location code groupings, frequency distributions of physical parameters for models, and physical distributions of microenvironmental concentrations. These files are all specified by the user, allowing for the inclusion of data pertinent to the populations and pollutants of interest.

The manual is divided into three major sections. The basis and mathematical structure of THEM is outlined in Sections I and II. Section III contains instructions and information for the users of THEM. Programmers who wish to modify the THEM program can find the information they need in Section IV.

Notice to Users: This document is intended for scientists in the field of exposure or risk analysis who wish to conduct calculations of population exposure using the THEM program. THEM should be used by individuals who have a clear understanding of the scope of human exposure analysis and the structure of human activity pattern data.

Technical Notice to Users: THEM is a group of stand-alone computer programs for use with the DOS operating system on IBM-compatible XT, AT, 386, 486, etc., personal computers. THEM is capable of being executed with any monitor configuration and does not require a math coprocessor. It requires no additional files and uses no special non-text file formats. On a 33 MHz 486 IBM-compatible computer, THEM takes about 20 minutes to calculate total human exposure for every 400 people.

Notice to Programmers: THEM was written in Microsoft Extended QuickBASIC version 7.1. The QuickBASIC programming language is completely modular and structured. It is possible with QuickBASIC to produce understandable code very quickly. A brief description of the structure used in THEM is available in Part 1 of Section IV of this manual. For more information on the language please consult the QuickBASIC manual[13] or contact Microsoft.

ACKNOWLEDGMENTS

This research was supported by funds provided by the Cigarette and Tobacco Surtax Fund of the State of California through the Tobacco Related Disease Research Program of the University of California, Grant No. 2RT0274. Grateful appreciation is extended to Wayne Ott for his constructive criticisms and to Paul Switzer for his helpful insights. Appreciation is given to the U.S. Environmental Protection Agency (EPA) for its support in developing some of the models and collecting some of the data used in this program. Thanks are extended to John P. Robinson for his help with the CAP data base and to Elena Tracy for her assistance with the CAP data base and BASIC computer programming. Appreciation is given to Peggy Jenkins and Tom Phillips of the California Air Resources Board for conducting the California Activity Pattern (CAP) Survey and making the data available to us.

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BACKGROUND

The frequency distribution of exposures across a population is crucial for conducting risk analyses. However, the task of measuring exposures for all people, including daily, weekly, and seasonal variations, even just for one pollutant, is quite a difficult and expensive proposition; and since exposures for different pollutants can vary widely between people, studies involving small numbers of people can be very misleading. There are two major methods for arriving at exposures across a population: a "direct" and an "indirect" method[14,15].

The direct method involves the simultaneous sampling of real exposures and activity patterns from a defined population, and creating exposure statistics from these data. Exposure data are collected with personal monitors attached to individuals as they conduct and record their daily routines. This method is fairly massive since it requires a day-long committment of many persons and careful quality control for small, rugged instruments, often followed by chemical analysis.

The indirect method, as exemplified by THEM, combines information on human activity patterns with information on the pollutants likely to be found there. Activity pattern information consists of samples of the daily locations and activities of a defined population. Microenvironmental concentrations are measured separately for the population, and used to develop mass balance models or frequency distributions of typical exposures in each microenvironment. The indirect method allows the problem of exposure estimation to be broken down into smaller segments. Activity patterns for a population can be obtained from fairly short random phone interviews, and microenvironmental concentrations can be obtained from short visits to various places individuals in the population typically visit or from intensive studies of pollutant flow in real locations or in laboratories. Measurements are still required, but instead of instruments worn by people, scientists measure and model the concentrations in the microenvironments that people visit.

THEM generates location, activity, and exposure "profiles" that consist of 1440-minute arrays containing location and activity codes (Figure 1), or RSP concentrations (Figure 2).

LOCATION FOR PERSON # 5 / PID # 101 / d:\californ\BAY.DAT
Grid of 24 hours vs. 60 minutes per hour

HRS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
MINS																								
1=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
2=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
3=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
4=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
5=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
6=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
7=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
8=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
9=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
10=	4	4	1	1	1	1	1	1	1	6	4	4	4	4	4	4	4	4	4	4	4	4	4	6
11=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
12=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
13=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
14=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
15=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
16=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
17=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
18=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
19=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
20=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
21=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
22=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
23=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
24=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
25=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
26=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
27=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
28=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
29=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
30=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
31=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
32=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
33=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
34=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
35=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
36=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
37=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
38=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
39=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
40=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
41=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
42=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
43=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
44=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
45=	4	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
46=	6	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
47=	6	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
48=	6	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
49=	6	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
50=	6	4	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
51=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
52=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
53=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
54=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
55=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
56=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
57=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
58=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
59=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
60=	4	6	1	1	1	1	1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1

Figure 1. Example of location profile. Minutes run vertically and hours run horizontally over grid containing location codes for person #5 of Bay Area activity file.

```
*******************************************************************************
EXPOSURE FOR PERSON #  5 / PID # 101 / d:\californ\BAY.DAT
Vector grid of 24 hours vs. 60 minutes per hour
 HRS- 1      3     5     7     9    11    13    15      17      19      21      23
MINS     2      4     6     8    10    12    14     16      18      20      22      24
--|-----------------------------------------------------------------------------
  1=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
  2=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
  3=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
  4=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
  5=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
  6=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
  7=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
  8=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
  9=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
 10=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107  0
 11=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 12=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 13=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 14=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 15=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 16=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 17=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 18=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 19=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 20=161 308  0  0  0  0  0  0  0  0  0  0  0  0  107 107 107 107 107 107 107 107 339
 21=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 22=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 23=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 24=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 25=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 26=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 27=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 28=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 29=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 30=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 31=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 32=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 33=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 34=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 35=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 36=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
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 40=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 41=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 42=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 43=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 44=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 45=161 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 46=  0 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 47=  0 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 48=  0 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 49=  0 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 50=  0 308  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 51=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 52=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 53=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 54=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 55=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 56=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 57=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 58=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 59=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
 60=308   0  0  0  0  0  0  0  0  0  0  0  0  0 107 107 107 107 107 107 107 107 339
-------------------------------------------------------------------------------
```

Figure 2. Example exposure profile. Minutes run vertically and hours run horizontally over grid containing average microenvironmental RSP concentrations ($\mu g/m^3$) for person #5 of Bay Area activity file.

The exposure for person *i* at minute *j* can be represented by

(1) $$E_{\mathcal{M}}(i,j) = f\left[L(i,j), A(i,j), S(i,j)\right]$$

where

$E_{\mathcal{M}}(i,j)$ = Microenvironmental exposure for person i at minute j

$L(i,j)$ = Location for person i at minute j

$A(i,j)$ = Activity for person i at minute j

$S(i,j)$ = Presence of smoker for person i at minute j

Microenvironmental exposures, $E_{\mathcal{M}}(i,j)$, are measured in concentration units such as $\mu g/m^3$ or ppm. Locations, *L(i,j),* are places such as home, bar, restaurant, work, car, bingo game, etc. Activities, *A(i,j),* include taking a shower, sleeping, vacumning, cooking dinner, driving to work, refinishing furniture, etc. The presence of a smoker, *S(i,j),* is also taken into account. THEM calculates microenvironmental exposures $E_{\mathcal{M}}(i,j)$ for each person by inputting locations, activities and the presence of a smoker and calling a subprogram -- called an $\mathcal{M}$-subprogram-- that fills in the minutes with appropriate pollutant concentrations. THEM uses the Monte-Carlo inverse transform method[16,17] to sample from frequency distributions of physical parameters and/or frequency distributions of microenvironmental concentrations.

Note: The current verson of THEM uses the Sequential Cigarette Exposure Model (SCEM) to calculate microenvironmental particle exposures due to Environmental Tobacco Smoke (ETS)[3]. SCEM comprises an $\mathcal{M}$-subprogram that is called whenever a single smoker is present in any location. It fills in each minute of the exposure array with an average particle concentration.

The ambient exposures are added to microenvironmental exposures to obtain total exposures

(2) $$E_{\mathcal{T}}(i,j) = E_{\mathcal{M}}(i,j) + E_{\mathcal{A}}(i,j)$$

where

$E_{\mathcal{T}}(i,j)$ = Total exposure for person i at minute j

$E_{\mathcal{M}}(i,j)$ = Microenvironmental exposure for person i at minute j

$E_{\mathcal{A}}(i,j)$ = Ambient exposure for person i at minute j

Ambient exposures are obtained from one or more fixed station monitors operating in the regional area where THEM is applied. The ambient data include the seasonal and daily fluctations in exposure from outside sources such as vehicles or wood smoke.

As THEM cycles through each person, it calculates 24-hour microenvironemental and ambient average exposures, maximum minute-by-minute micronenvironmental exposures, and maximum hourly total exposures. It also outputs the age and sex of each person obtained from the original activity pattern diaries and optionally outputs the amount of time each person was exposed in each location. More detailed discussion of the structure of THEM is available in another paper[12].

USER'S SECTION

This section describes the aspects of THEM that a user must be familiar with so that he/she can: (1) Calculate Population Exposures, (2) Specify Input and Output Files, (3) Modify Location and Activity Groupings, (4) Set Calculation Options, (5) Set Display Options, (6) Specify Frequency Distributions for Microenvironmental Model Parameters, (7) Specify Frequency Distributions for Microenvironmental Concentrations, (8) Create Histograms and Statistics for Human Exposures. Through (6) and (7) above, the user can easily improve the accuracy of THEM calculations by using more reliable input data based on field studies and experiments.

Note: All executable programs are written in capital letters (e.g., THEMMAIN) in the following discussions.

The THEM Suite of Programs

The methodology for computing frequency distributions of exposure is split into several different computer program modules: THEMMAIN, THEMHIST, CALCHIST, and VIEWHIST. This was done for three primary reasons: (1) memory considerations, (2) to simplify the programming, and (3) to clarify the step-wise progress of calculations for users. The first program (THEMMAIN) is the actual engine for producing exposure data from activity patterns, microenvironmental surveys, and indoor models. This program can be used alone to tabulate lists of exposure, demographic data, and exposure times for each person in the population. The output of THEMMAIN can then be used with a statistical package for analyzing the data. Alternatively, the second THEM program (THEMHIST) can be used easily to calulate histograms, averages, standard deviations, medians, number of exposed people, percent of exposures over a certain threshold, and other statistics relevant to exposure analysis. The remaining two THEM programs produce histograms of the frequency distributions for the physical parameters and microenvironmental concentrations that are used as input to THEMMAIN (CALCHIST), and display graphical representations of histograms produced by any of the THEM programs (VIEWHIST). Most of the discussion in the next few parts centers around the THEMMAIN program.

User Interface

The user interface in all of the THEM programs consists of key-controlled menus. Each menu contains a title, a list of tasks or options, and instructions. The user selects a choice from the lists of tasks or options by pressing a letter or number. To exit a menu, the user usually presses either the "Return" or "Escape" key.

During calculations in the THEMAIN program, the user is presented with a screen displaying information about the calculation-in-progress. The person number, identification number, last microenvironmental exposure, current task, etc., are all updated as THEM processes each person. Depending on the options the user has chosen, THEM may save, display on the screen, or print information on each person. Instructions are displayed in a window at the bottom of the screen.

Main Calculation Choices. With THEMMAIN, the first screen the user sees is the title screen. After pressing any key, the user sees the "Main Title" screen containing all the major calculation options. The first section of the "Main Title" screen has options for: (1) carrying out a "detailed" calculation for the next person, (2) calculating exposures for everyone in the activity pattern input file (APIF), and (3) calculating exposures for the next N persons in the APIF. The detailed calculation for (1) displays for the user the location, activity, exposure, and hourly summary profiles as the program conducts a calculation for only the next person in the APIF. The second section of the "Main Title" screen allows for the control of position in the APIF. The third section contains options leading the user to menus for changing display options, input and output filenames, and calculation options.

Input and Output Files

The user can change the name of all input and output filenames (Table 1) by pressing "O" at the "Main Menu". He/she is then presented with a list of the current filenames that are altered by pressing the appropriate letter and entering the new name. All names must also contain the desired path, otherwise THEM assumes they are in the same as the directory where the THEMMAIN program was started.

Table 1. Acronyms for Input and Output File Names

APIF	Activity Pattern Input File
AIF	Ambient Input File
PEOF	Population Exposure Output File
TOF	Output File for Tally of Exposure Time in Each Location
LOF	Output File for All Location Profiles
AOF	Output File for All Activity Profiles
SOF	Output File for All Smoker Present Profiles
EOF	Output File for All Exposure Profiles
HOF	Output File for All Hourly Exposure Summaries
MOF	Output File for All Exposure Episode Model Parameters

The APIF, AIF, and PEOF filenames cannot be null since they are required in any calculations of exposure. Exposures are automatically written to the PEOF for every person cycled through the THEMMAIN program. If the other output file names are null, then none of the corresponding information will be written to a file. Information is appended to these files for

each cycle. The user is required to erase the files manually to erase unwanted data from previous calculations.

THEM Data Files

THEM requires two data files to carry out its calculations: (1) THEMLOC.DATA, and (2) THEMDIST.DAT. THEMLOC.DAT contains the location names, old codes, and calculation method for each of the new regrouped location codes. The old codes are the standard codes used during the collection of actual activity pattern data (Table 2). The calculation method involves either a mass balance model or sampling from a distribution of actual microenvironmental data. The four-character code corresponding to the calculation method must be recognized by the THEMMAIN program. Currently, the only method codes recognized are "SCEM" for the Sequential Cigarette Exposure Model and "MICR" for the sampling of micronenvironmental concentration data. THEMDIST.DAT contains the frequency distributions for the mass balance model parameters and for microenvironmental concentrations. Examples of both files -- with instructions for their use -- are included in Appendices B and C. To help the user check the input distribution, CALCHIST reads the frequency distributions in the THEMDIST.DAT data file and displays histograms of sampled values.

Although adding a new microenvronmental model requires the user to program a new BASIC subprogram, adding new microenvironmental exposure data obtained from real monitoring studies involves only the modification of the THEMDIST.DAT text file. The number of locations is input into THEMMAIN from the THEMLOC.DAT text file and THEMMAIN expects to find distributions corresponding to each of these locations at the end of the THEMDIST.DAT text file. THEMMAIN requires a "99,99" flag at the end of each distribution data line. The format is described in the file itself (Appendix B).

Calculation Options

THEMMAIN allows for the exclusion of specific microenvironmental locations from population exposure calculations. It also is possible from within THEMMAIN to change the calculation method used to determine exposures in each microenvironment.

The utility of exposure models such as THEM lies in their ability to predict the effect of specific control stategies on population exposure as long as other exposure factors remain the same. For example, if smoking tobacco were prohibited in bars and restaurants, what would be the resulting reduction in 24-hour ETS exposures for the defined population? If no other human behavior had been changed due to this policy decision, the analyst could use the same activity pattern and exposure data as before and simply set all exposures in bars and restaurants to zero.

To conduct such a calculation in THEMMAIN is very simple. From the "Options, Filenames" menu, the user should press "1" for "Exclude Locations". Next, the user should enter the number of the location you wish to exclude. For calculations that include the exposures for only one microenvironment, just exclude all locations except for the one desired.

The calculation method for each location can be changed by pressing "2" at the "Options, Filenames" menu. When the number of the appropriate location is entered, the program cycles through the available calculation methods (e.g., SCEM or MICR). The algorithm corresponding to each calculation method must be present in a subprogram of the THEMMAIN program module (see the "Programmer's Section" of this manual). Frequency distributions for the parameters required by any models and frequency distributions for microenvironmental concentrations must both be present in the THEMDIST.DAT text file.

Display & Printout Options

The THEM user has access to the following data: (a) location and activity profiles, (b) exposure files, (c) hourly summaries, (d) graphical represention of daily profiles, and (e) exposure episode parameter list for every person cycled during a calculation. This data is available through: (1) display on monitor screen, (2) printouts, or (3) files on a computer disk. The user also can have THEMMAIN pause between the calculation of each person, or pause when a new exposure episode is encountered. These options are accessed by pressing "C" at the "Main Menu" and toggling each option by pressing the appropriate number.

Example Calculation

This part of the manual presents an "example calculation" of 24-hour average Respirable Suspended Particles (RSP) exposures from Environmental Tobacco Smoke (ETS) and ambient levels for the San Francisco Bay Area. The activity pattern file used as input is part of the California Activity Pattern (CAP) Survey[1,2,3,4]. In this example, the PM-10 RSP ambient data was obtained from a BAAQMD fixed-station monitoring site in San Jose, CA[8]. The SCEM cigarette exposure model was used to calculated PM-3.5 microenvironmental exposures for all the reduced locations in Table 3; that is, no frequency distributions of actual microenvironmental concentrations were used in this example. All model parameters were estimated by the author except for the residential air exchange rates[6], and residential areas (footages) and number of rooms[7]. The frequency distributions estimated by the author in THEMDIST.DAT are for vehicle volumes, vehicle window-open/window-closed air exchanges, sources strengths, and smoking rates. The THEMLOC.DAT and THEMDIST.DAT files used for this calculation are given in Appendices A and B. The conversion factor from PM-10 ambient concentrations to PM-3.5 concentrations was chosen as 0.6[18] in the subprogram that read the BAAQMD file. All parties involved in this research realize that use of a single conversion factor for PM 3.5/PM 10 is an oversimplification.

However, a special real-time monitoring field study conducted and analyzed at Stanford University[19] compared PM 2.5 reading with the BAAQMD values of PM 10. Although the results of this unpublished research showed that the ratio varied from day to day, its range was between 0.4 and 0.8. Use of 0.6 is an approximation.

Input Files. The text files BAY.DAT and PART.DAT contain the Bay Area Activity Pattern and ambient data, respectively (Figures 3 and 4).

```
31,3,1,0,230,150,150,2,5,91,10,17,87,7
31,0,426,475,707,838,0,2,101887,1,1,1,1,5,2,0,0,0,0,0,0,0,0,0
31,5,0,5,0,0,0,5,0,0,5,0,0,0,0,0,0,0,0,1,1,1,7,720,720,5,0,5,0,5,5,5,5,5
31,0,1,1,5,5,5,5,5,5,40,6,0,5,95492,49,1,1,1,0,1,5,1,0,0,0,0,1,5,3,1,5
31,0,0,0,0,0,0,0,0,0,1,5,0,5,0,0,0,5,0,0,5,0,0,0,0,0,0,0,5,5,5,5,5,0
31,1,1,1,1,5,14,9,5,101887,0,1,53,24,3,0,3,3,2,24,39,5,5,1,1,10,17,87
31,7,10,17,87,7,0,10,17,87,7,10,17,87,7,0,0,0,.643,.5895,.9258,.541
31,3,1,230,400,90,240,4,5,474,10,17,87,7
31,3,1,400,1100,420,660,5,0,45,10,17,87,7
31,3,1,1100,1115,15,675,4,5,40,10,17,87,7
31,3,1,1115,1215,60,735,1,5,43,10,17,87,7
31,3,1,1215,1400,105,840,5,5,65,10,17,87,7
31,3,1,1400,1500,60,900,1,5,43,10,17,87,7
31,3,1,1500,1700,120,1020,5,5,54,10,17,87,7
31,3,1,1700,1800,60,1080,2,5,43,10,17,87,7
31,3,1,1800,2300,300,1380,2,5,91,10,17,87,7
31,3,1,2300,2330,30,1410,1,5,43,10,17,87,7
31,3,1,2330,2400,30,1440,2,5,43,10,17,87,7
33,3,3,0,1000,600,600,5,0,45,10,17,87,7
33,0,426,475,707,838,0,2,101887,1,1,1,1,5,2,0,0,0,0,0,0,0,0,0
33,5,0,5,0,0,0,5,0,0,5,0,0,0,0,0,0,0,0,1,1,1,7,720,720,5,0,5,0,5,5,5,5,5
33,0,1,1,5,5,5,5,5,5,40,6,0,5,95492,49,1,1,1,0,1,5,1,0,0,0,0,1,5,3,1,5
33,0,0,0,0,0,0,0,0,0,1,5,0,5,0,0,0,5,0,0,5,0,0,0,0,0,0,0,5,5,5,5,5,0
33,1,1,1,1,5,14,9,5,101887,0,1,53,24,3,0,3,3,2,24,39,5,5,1,1,10,17,87
33,7,10,17,87,7,0,10,17,87,7,10,17,87,7,0,0,0,.643,.5895,.9258,.541
33,3,3,1000,1045,45,645,5,5,96,10,17,87,7
33,3,3,1045,1115,30,675,4,5,40,10,17,87,7
33,3,3,1115,1145,30,705,5,5,47,10,17,87,7
33,3,3,1145,1230,45,750,4,5,40,10,17,87,7
33,3,3,1230,1300,30,780,2,5,91,10,17,87,7
33,3,3,1300,1320,20,800,51,5,39,10,17,87,7
33,3,3,1320,1845,325,1125,24,5,31,10,17,87,7
33,3,3,1845,1900,15,1140,51,5,39,10,17,87,7
33,3,3,1900,1915,15,1155,1,5,10,10,17,87,7
33,3,3,1915,2000,45,1200,5,5,80,10,17,87,7
33,3,3,2000,2030,30,1230,2,5,43,10,17,87,7
33,3,3,2030,2200,90,1320,2,5,91,10,17,87,7
33,3,3,2200,2230,30,1350,5,5,96,10,17,87,7
33,3,3,2230,2300,30,1380,4,5,40,10,17,87,7
33,3,3,2300,2320,20,1400,51,5,79,10,17,87,7
33,3,3,2320,2400,40,1440,31,5,86,10,17,87,7
continued...
```

Figure 3. The entries for the first two people in the BAY.DAT activity pattern data file for the San Francisco Bay Area consist of demographic and diary data. Each diary line (the shorter ones) contains: the personal identification number, adult vs. youth code, beginning time, ending time, cumulative time, location code, presence of a smoker code, activity code, month, day, year, and day of week. The demographic data (longer lines) contains various information on sex, age, education, housing, etc.

```
87001 13 14 12 10  8  7  5  4  4  7  7  4  5  8  8  6 10 18 22 35 55 66 72 75
87002 81 62 74 55 53 43 40 46 28 22 15 16 13 -1  5 -1  9 12  9 19 44 67 92 96
87003100 93 80 74 53 43 31 28 21 22 21 21 -1 -1 -1 -1  3  8 23 47 70 82 65 44
87004 43 35 22 27 17 17 31 59 63 49 15 12 19 18 21 14 24 44 57 45 61 54 57 44
87005 25  9 10 13 11 12 25 33 36 40 28 30 30 72 58 48 32 26 24 21 22 22 26 26
87006 25 26 23 25 22 23 26 30 30 29 28 24 21 23 33 34 30 35  4 -1 -1  1  2  2
87007 -1 -1  3  2 -1  4  8 15 15 14  9  5  4 12  9  6  5 12 15 18 20 31 27 19
87008  9  5  3  3  5  5  8 10 11 14 18 17 14  9 12  9  8 10 10 13 18 26 46 37
87009 35 39 32 19 11  8 11 10 17 10 11  9 14  8 10  7  9  8 12 17 15 19 14 14
87010  6  4  2  4  5 10  8 13 19 11  6  7  7  9 13  6 10  7 14 27 26 53 56 44
87011 33 15 18  9  7 10 12 18 22 22 19 11 10  8 13 11 13 29 34 35 32 50 30 48
87012 28 41 43 37 34 42 29 41 45 56 39 35 28 35 32 13  3  4  7  6  5  5  6 12
87013 15  5  3  4 10 14 13 16 13 13 17  7  6 11 15 12 11  8  9  3  5  4  4  6
87014  8  9 -1 -1 -1 15 17 22 21 14 12 15 14 17 13 17 22 25 32 24 26 29 31 42
87015 21 13 17 14 10 16 16 28 16 13  7  4  5  5  6 -1 -1 -1  6 11  6  6  8  5
87016  6 10 12 13 10  6  9 10 15 18 12 15 16 17 16 17 17 18 21 23 31 47 60 61
87017 66 31 37 19 36 20 25 25 14  5 -1 -1 -1  4  4  6  8  6  5  6  4  5 12 18
87018 21 20 17 10  9  9 11 14 15 15  8  8  8 11 11 11 13 17 20 33 24 20 24 25
87019 27 27 36 30 29 28 27 43 46 30 20 18 16 16 20 19 16 12  9 11 10 10  9 10
87020  8  8  7  7  7  7  7  6 12 12 12 10  7  9 10 10 11 14 10  8  8 10 18 18
continued...
```

Figure 4. The ambient data file PART.DAT consists of lines corresponding to each day in 1987 (the first 20 days are shown). Each line contains the Julian date (number of days after first of the year) and the average concentration of PM-10 RSP (in $\mu g/m^3$) for each hour measured at the BAAQMD site in San Jose, CA.

Location Regroupings. For this example, the standard locations codes used in the CAP data base were regrouped into six new location codes (Table 2): (1) Home, (2) Office-Factory, (3) Other Indoor, (4) Bar-Restaurant, (5) Outdoors, and (6) Vehicle.

Table 2. Location Codes Used in the CAP Survey[1,2] and Regrouped Codes input into THEMMAIN from THEMLOC.DAT

Standard Location Codes		**Regrouped Location Codes**		
Code	Location	Code	Location	Standard Codes
1	IN KITCHEN	1	INSIDE HOME	1-9, 12-13, 32
2	IN LIVING ROOM			
3	IN DINNING ROOM	2	OFFICE-FACTORY	21-22, 38
4	IN BATHROOM			
5	IN BEDROOM IN GARAGE	3	BAR-RESTAURANT	28-29
6	IN STUDY			
7	IN GARAGE	4	OTHER INDOOR	23-27,30,31,
8	IN BASEMENT			33,35-37,39
9	IN UTILITY ROOM			
10	POOL, SPA	5	OUTDOORS	10, 11, 34,
11	IN YARD			40, 53, 54, 59
12	ROOM TO ROOM			
13	OTHER HOUSEHOLD ROOM	6	VEHICLE	51, 52, 55-58,
21	AT OFFICE			60-61
22	AT PLANT			
23	AT GROCERY STORE			
24	AT SHOPPING MALL			
25	AT SCHOOL			
26	OTHER PUBLIC PLACE			
27	AT HOSPITAL			
28	AT RESTAURANT			

29	AT BAR-NIGHTCLUB	
30	AT CHURCH	
31	AT INDOOR GYM	
32	AT SOMEONE ELSE'S HOME	
33	AT AUTO REPAIR	
34	AT PLAYGROUND	
35	AT HOTEL-MOTEL	
36	AT DRY CLEANERS	
37	AT BEAUTY PARLOR	
38	AT WORK:MOVING AMONG LOCATIONS	
39	OTHER INDOOR	
40	OTHER OUTDOOR	
51	IN CAR	
52	IN VAN	
53	WALKING	
54	AT BUS STOP	
55	ON BUS	
56	ON RAPID TRAIN	
57	OTHER TRUCK	
58	ON AIRPLANE	
59	ON BICYCLE	
60	ON MOTORCYCLE	
61	OTHER TRANSPORTATION	
99	UNKNOWN	

Execution of THEM. The procedure for executing a THEM calculation involves setting calculation options, filenames, display-save-print options, etc. (Table 3).

Table 3. Checklist for Execution of an Exposure Calculation Using THEM

1.	Activity, ambient input files are in the correct format
2.	THEMLOC.DAT file contains the correct location categories and old location codes with correspondng calculation method
3.	THEMDIST.DAT file contains the correct frequency distributions for mass balance parameters and for microenvironmental concentrations (VIEWHIST may be used)
4.	Start THEMMAIN program
5.	Input and output filenames are correct (Choose "O" from main menu for "Options, Filenames" menu)
6.	Options for excluding microenvironements are correct
7.	Options for calculation method in each microenvironment are orrect
8.	Option to include ambient data is correct
9.	Options for printing and displaying calculation results/progress re correct (Choose "C" from main menu for "Print, Display ptions" menu)

10.	Choose "D", "A", or "N" from main menu for "detailed", "all", or "n-person" exposure calculation
11.	View the calculation screen while exposures and, if opted, exposure times, location, activity, smoker, and hourly profiles, and episode parameters are tabulated in the appropriate files; this information may be displayed on the screen or printed if appropriate options were set
12.	Output files do not contain any obvious errors
13.	Repeat above checklist for any additional exposure calculations
14.	Quit THEMMAIN program
15.	Start THEMHIST program
17.	Proper path and filename are set for file containing exposures outputed from THEMMAIN
18.	Input desired number of people from tabulated list of exposures (Choose "R" for "read in file" from "Action Menu")
19.	Select desired population subdivisions for histograms (Choose "V" for "view" under the "Action Menu" and set options)
20.	Produce desired histograms ("O" on the "View Summaries" menu allows modification of histogram options such as barwidth, number of bars, start, end etc.)
21.	Save histograms and statistics (Choose "H" from "View Summaries" menu)

THEM was run with no locations excluded and the SCEM method was selected for each location. All 381 people in the BAY.DAT file were processed in THEMMAIN with the "All" calculation option (see ***Main Menu Choices*** under **User Interface** above). The population exposure output file produced from THEMMAIN included the 24-hour average and hourly maximum RSP exposures for each person (Figure 5). Exposure times were also tallied and output for each person (Figure 6).

SUMMARY OF 24-HOUR AVERAGE HUMAN RSP EXPOSURES (ug/m3)

#	PID	A	S	X	Ave. Micro.	Max.Min.Micro.	Ave. Ambient	Tot.Hour.Max.
1	31	40	5	0	0.00	0.00	24.97	62.40
2	33	40	5	0	0.00	0.00	24.97	62.40
3	41	29	1	0	0.00	0.00	24.97	62.40
4	71	75	5	0	0.00	0.00	23.30	35.40
5	101	32	1	1	68.36	339.15	26.68	368.42
6	141	39	1	0	0.00	0.00	23.30	35.40
7	143	39	1	0	0.00	0.00	24.97	62.40
8	171	49	5	1	280.58	841.73	11.75	856.73
9	201	36	1	0	0.00	0.00	24.97	62.40
10	251	49	5	0	0.00	0.00	24.97	62.40
11	271	62	1	1	10.92	184.97	14.54	200.57
12	321	24	1	1	2.70	6.83	0.00	6.23
13	411	21	1	0	0.00	0.00	21.80	46.80
14	421	34	5	0	0.00	0.00	8.33	22.20
15	431	42	1	1	79.80	1429.65	11.40	663.49
16	491	47	5	0	0.00	0.00	24.97	62.40
17	493	47	5	1	85.10	434.31	24.38	450.73
18	531	25	5	0	0.00	0.00	13.30	33.00
19	601	29	5	0	0.00	0.00	13.10	30.60
20	611	24	5	1	12.43	149.11	23.30	166.51

continued...

(c:\them\basic\bay.dat, OOOOOO, SCEM.SCEM.SCEM.SCEM.SCEM.SCEM., N)

Figure 5. The first twenty people in the exposure output file for the Bay Area (381 persons total). The last line of the file contains, in parentheses: the name of the activity pattern input file, a string containing O's for each microenvironment included and X's for each microenvironmenta not included, a string containing the calculation method for each microenvironment (separated by periods), and the calculation type ("N", "All", or "detailed").

TALLY OF MINUTES OF EXPOSURE FOR EACH PERSON
IN EACH OF 6 LOCATIONS

#	PID	AT H	OFFI	OTHE	BAR,	OUTD	VEHI	TOT
1	31	0	0	0	0	0	0	0
2	33	0	0	0	0	0	0	0
3	41	0	0	0	0	0	0	0
4	71	0	0	0	0	0	0	0
5	101	50	0	0	625	0	0	675
6	141	0	0	0	0	0	0	0
7	143	0	0	0	0	0	0	0
8	171	0	0	480	0	0	0	480
9	201	0	0	0	0	0	0	0
10	251	0	0	0	0	0	0	0
11	271	85	0	0	0	0	0	85
12	321	0	570	0	0	0	0	570
13	411	0	0	0	0	0	0	0
14	421	0	0	0	0	0	0	0
15	431	190	0	135	0	0	70	395
16	491	0	0	0	0	0	0	0
17	493	415	0	180	0	0	20	615
18	531	0	0	0	0	0	0	0
19	601	0	0	0	0	0	0	0
20	611	120	0	0	0	0	0	120

continued...

(c:\them\basic\bay.dat, OOOOOO, SCEM.SCEM.SCEM.SCEM.SCEM.SCEM., N)

Figure 6. The first twenty people in the output file containing tally of exposure times in each microenvironment for the Bay Area (381 persons total). The last line is explained in the caption for

Figure 3 .

Next, the THEMHIST program was used to generate a histogram of 24-hour average microenvironmental exposures for the population from which the mean, median, standard deviation, number of people exposed, percent over state standard, and percent over the federal standard were obtained (Table 4). THEMHIST can also be used to generate statistics involving any of the other variables.

Table 4. Overall statistics for the 24-hour average RSP microenvironemental exposures from ETS ($\mu g/m^3$) for the San Francisco Bay Area (381 people total)

Median	Mean	Standard Deviation	No. of people exposed at least 1 min.	% over 50 $\mu g/m^3$ (California 24-hour Standard)	% over 100 $\mu g/m^3$ (U.S. 24-hour Standard)
19-20	68	128	184	32	13

PROGRAMMER'S SECTION

This section provides the information necessary to modify THEM. While user's are able to change the population activities, location codes, typical mass balance model parameters, and typical microenvironmental concentrations, all without writing any new BASIC code, scientists interested in studying exposures with new models must write a new *M*-subprogram to calculate minute-by-minute exposures. Changes must also be made in THEM so it will input the proper distributions and properly branch to new subprograms when new models are added for a specific locations. Thus, THEM can be constantly expanded so as to produce more sophisticated and accurate results.

If activity pattern or ambient data files of non-ASCII formats are desired, then a subroutine must be written to read them in. Only the sections in the ProcessPerson subprogram involving input must be changed.

Microsoft QuickBASIC

THEM was written in Microsoft Extended Professional QuickBASIC version 7.1. QuickBASIC supports the use of separate modules which must be loaded prior to execution of the program. Each of these modules contains independent procedures (subprograms or functions), and/or variable and type declarations. They are linked together by the use of INCLUDE files containing procedure, global variable, and type declarations. Each module has an INCLUDE file associated with it. The procedures in a module may be accessed if the calling module has "included" the corresponding INCLUDE file and the variables can be accessed if they have been preceded in the INCLUDE file by the COMMON SHARED statement. For THEM, the file THEMDECS.BI contains all global variable and type declarations (preceded by COMMON SHARED), and procedure declarations for the Main Module (THEMMAIN.BAS). Each other module (THEMIO.BAS, THEMSTAT.BAS) "includes" THEMDECS.BI if it needs to access its procedures, variables, or types. Please see the Microsoft QuickBASIC Manual for detailed information on programming with modules and procedures.

Style Conventions

All filenames in THEM are written in capital letters (e.g., THEMMAIN.BAS, THEMDECS.BI). Variables are also written in capital letters (e.g., NUMRECORDS%, INPUTFILE$; ending with the appropriate type identifier, %=Integer, &=Long Integer, $=String, none=Single Precision Real). Procedures (subprograms and functions) are written with initial capital letters (e.g., CalculateExposure, ShowParamsMenu, GetFromStringS).

The Subprograms

There are over 70 procedures (subprograms and functions) used by THEM. They are divided into four program modules and five other separate modules. The four programs (Table 5) are: (1) Main Module (THEMMAIN.BAS), (2) Histogram Calculating Module (THEMHIST.BAS), (3) Distribution Checking Module (CALCHIST.BAS), and (4) Histogram Viewing Module (VIEWHIST.BAS). THEMMAIN contains the main THEM logic loop and subprograms that carry out tasks peculiar to THEM. These include: (1) reading input files, menus, array handling, (2) algorithms for the calculation of exposure, and (3) exposure profile output (Table 6). THEMHIST is used for calculating histograms of the exposures output by THEMMAIN. CALCHIST is used for checking the parameter and microenvironmental concentration frequency distributions contained in the THEMDIST.DAT file. VIEWHIST actually displays a histogram on the screen using BASIC's presentation graphics routines. Each of the four program modules contains procedures specific to themselves.

Table 5. Modules Comprising the THEM Suite of Programs

Program Module	**Sub-Modules Used**
THEMMAIN *Calculates population exposures from activities, and parameter or concentration frequency distributions*	GENIO, GENSTAT
THEMHIST *Creates histograms from THEM population exposures*	GENIO, THEMIO, GENSTAT, THEMSTAT
CALCHIST *Calculates and displays histograms for model parameters or microenvironmental concentration frequency distributions used in THEM*	THEMGRX, THEMSTAT, GENIO
VIEWHIST *Displays histograms that have been saved to a file by other programs (THEMMAIN, THEMHIST)*	THEMGRX, GENIO

Each module has its own, separate "include" file (*.BI) containing all its procedure, type, and variable declarations.

Table 6. List of Procedures in THEMMAIN

Module	Subprogram	Short Description
THEMMAIN *Main module containing procedures for calculating population exposures*	AmbExp	Gets ambient hourly average exposure data from D. Fairley, BAAQMD file.
	CalculatePerson	Handles calculation of exposure for each person
	Calender	Translates CAP date to Julian format
	ClearProfile	Erases profiles (location/smoking)
	ClearVector	Erases vector profiles (exposure)
	ConstantExposure	Determines constant exposures based on location, smoking, and activity
	ConstMenu	Displays menu for user to change constant exposure values
	Diary	Processes the CAP diary information for each person
	DoTitle	Displays title on the screen
	EnterDist	Enters the parameters for arbitrary user-specified distributions (range + cum. frequ.)
	EnterLNorm	Enters log normal or normal distribution parameters specified by the user
	Fill	Fills in the 1440 minutes of location, activity, smoker and exposure grids
	FindPersonID	Search input file for a specific PID#
	HistMenu	Displays the menu for user-specified histogram options
	Initialize	Intitializes global variables, sets options etc...
	MainMenu	Displays the main menu
	NewPerson	Resets global parameters to prepare for processing of next person
	OptionsMenu	Displays the options menu for filenames and calculation type
	PrintOutOptions	Displays menu for options to print calculation results or calculation progress to screen or line printer
	ProcessPerson	Control subprogram for the processing of each person
	ReadDistParams	Actually reads in the parameters from the file THEMDIST.DAT; called by EnterDist and EnterLNorm subprograms

	RegroupLoc	Regroups locations into any new locations specified by the user in THEMLOC.DAT
	RestartCalc	Reinitializes files pointers and global variables to restart calculation
	RetrieveOptions	Retrieves program options from THEM.OPT file
	SaveOptions	Saves program options into THEM.OPT file
	SCEM2	Calcualates RSP exposure from ETS based on SCEM model
	SCEMExp	"
	ShowGroupLoc	Displays regrouped locations
	ShowLocations	Displays original locations
	ShowParamsMenu	Displays menu for viewing distribution parameters as specified by the user in THEMDIST.DAT
	StorePerson	Saves 24-hour average microenvironmental, ambient, total, and hourly maxium total exposures for each person
	PrintHist	Prints a histogram to the printer
	PrintHourlySum	Prints the hourly summary of microenvironmental and ambient exposure to the line printer
	PrintProfile	Prints location and activity profiles to the line printer (integer number elements)
	PrintSCEM	Prints a list of all sets of SCEM parameters for one person to the printer
	PrintSummary	Prints a summary of all 24-hour average microenvironmental and ambient exposures to printer
	PrintVector	Prints exposure profile to the printer (real number elements)
	ReadAmbient	Reads hourly ambient data from a file for a specified Julian date
	SaveHourlySum	Saves the hourly of microenvironmental and ambient exposure for each person to file
	SaveProfile	Saves a location or activity profile (integer elements) to a file
	SaveSCEM	Saves all sets of SCEM model paramters for one person to a file
	SaveVector	Saves exposure profile to a file (real number elements)
	UpdateScreen	Updates screen during calculation of exposures

	WriteDist	Writes a frequency distribution to the screen
	WriteHourlySum	Writes summary of hourly exposures for one person to the screen
	WriteProfile	Writes a location or activity profile (integer elements) to the screen
	WriteVector	Writes exposure profile to file (real number elements)

The five other modules contain general procedures that are independent of the three major applications, but can be used by any of them (Tables 7 and 8): (1) General Input and Output (GENIO.BAS), (2) General Statistics (GENSTAT.BAS), (3) Statistics for THEM (THEMSTAT.BAS), (4) Input and Output for THEM (THEMIO.BAS), and (5) Graphics for THEM (THEMGRX.BAS). The Input and Output Modules contain routines for sending data to the screen, file, or printer; receiving user input from the keyboard, and string-handling. The Statistical Modules contain statistical functions (average, standard deviation, etc.), functions for sampling from distributions, and a subprogram for calculating histograms.

Table 7. Procedures in THEM-Specific Modules

THEMIO *Input and Output procudures specific to THEM*	SaveHist	Saves a histogram to file
	SaveSummary	Saves summary of all 24-hour average microenvironmental and ambient exposures to file
	ViewSummaries	Displays menu for viewing and saving summaries/histograms of population data
	WriteHist	Writes a histogram to the screen
	WriteSummary	Writes the summary of exposures across the population to the screen
THEMSTAT *Statistical Routines specific to THEM*	CalculateHist	Returns the histogram for a data array
THEMGRX *Presentation Graphics procedures used to display histograms*	DisplayBarChart	Displays a bar chart on the screen; Used by THEM for drawing histograms
	SetUpPresGRX	Sets up the screen and intializes variables for drawing a chart

Table 8. List of Procedures in "General" Modules

Module	Procedures	Description
GENIO *General Input and Output procedures*	ColorOn	Specifies color for screen text
	FillString	Enters a string of specified length with another string derived from numeric data
	GetAKey	Reads a key in from the keyboard; used for input from user during menu routines
	GetFromStringN	Gets a number from a string, _3_43_3.43_, with specified position: 1 2 3
	GetFromStringS	Gets a string from a string, _hello_there_, with specified position: 1 2
	LookAtFile	Displays contents of any text file on the screen with scrolling control
	OpenFile	Opens a file with error checking
	PlaceText	Positions color text on the screen
	PrinterControl	Sends commands to line printer
	RepeatCH	Displays a character repeatedly over a line on the screen
	SetPrintFont	Sets font for the attached printer
	SetPrintStyle	Sets print style for the attached printer
GENSTAT *General Statistical routines*	**Average**	Returns the average of a data array
	Die	Simulates the rolling of a die with a user-defined number of sides
	DistSample	Samples a real number from a distribution
	InvGausCDF	Returns a value for the inverse Gaussian cumulative distribution function
	LNormSample	Samples a value from a log normal distribution
	Maximum	Returns the maximum of a data array
	Minium	Returns the minimum of a data array
	NormSample	Samples a value from a normal distribution
	StandardDeviation	Returns the standard deviation of a data array
	Sum	Returns the sum of a data array

THEM is written in Microsoft Professional QuickBASIC v.7.1
Bold procedures are functions that return values depending on the parameters passed to them.
"Write" refers to displaying data on the screen
"Save" refers to saving data to a file on disk
"Print" refers to printing data to the attached line printer
"Vector" refers to arrays with real valued elements (exposures)
"Profile" refers to array with integer valued elements (location/acitivity codes)

The Flow of THEMMAIN

The Main Module contains the THEM control loop. This loop branches to procedures for: (1) Calculating Exposure, (2) Viewing Input Data, and (3) Changing Options. All subprograms that only display menus contain the word "Menu" at the end of their names (Table 6). The following subprograms work together to calculate exposure based on the location and smoking profiles: NewPerson, ProcessPerson, CalculatePerson, StorePerson. The CalculatePerson subprogram calls the *M*-subprograms MicroExp or SCEMExp that, in turn, calculate specific exposures based on constant exposures obtained from real microenvironmental measurements or from the Sequential Cigarette Exposure Model (SCEM), respectively.

Variables and Types

All global types, variables, and constants are declared in THEMDECS.BI (Tables 9, 10 and 11). All other variables are locally declared. The largest arrays used in THEM are the 1440-minute long location, activity, smoker, and exposure profiles, but these are declared locally in the ProcessPerson subprogram.

Table 9. Global types declared in THEMDECS.BI for THEMMAIN.BAS

Type	Description
TYPE SMPARAMS ACH AS SINGLE VOLUME AS SINGLE SMRATE AS SINGLE SOURCE AS SINGLE SMLOC AS SINGLE AVECONC AS SINGLE NUMROOMS AS SINGLE END TYPE	*Parameters for mass balance smoking models (e.g. SCEM): air exchange rate, volume, smoking rate, source strength, smoking location, average concentration and number of rooms. The model uses the other parameters to find a value for AVECONC.*

TYPE LOCCODES CODE AS INTEGER NAME AS STRING * 15 REGROUP(1 TO 100) AS INTEGER NGROUP AS INTEGER ETSDIST(2, 25) AS SINGLE EXCLUDE AS STRING * 1 SAMPLE AS SINGLE METHOD AS STRING * 4 TALLY AS INTEGER END TYPE	*New code, name, standard codes used, number of codes to regroup, distribution of microenvironmental concentrations, exclude flag, sampled value of concentration data, calculation method, exposure time tally for each location.* *Typically, THEM's method of calculation involves either sampling a value from a distribution OR it calculates a concentration using a model as specified by the 4-character METHOD variable.*
TYPE DEMOG AGE AS INTEGER SEX AS INTEGER PID AS LONG EXPOS AS INTEGER END TYPE	*Demographic data for each person: age, sex, personal identification number, and exposed flag (0 = unexposed; 1 = exposed)*

Table 10. Global variables declared in THEMDECS.BI for THEMMAIN.BAS

Variable	**Type**	**Description**
a.y, tbeg, tend, etim, ctim, where, DSMOKE, act, dirm, dird, diry, dirwkday	Single	*All parameters for each diary line: adult or youth code, beginning time, ending time, cumulative time, location code, smoking code, activity code, month, day, year, day of week*
ACTFILE$	String	*Activity profile output file*
ALLSTOP%	Integer	*Flag for exiting "all" calculation loop when interrupted by user*
AMBFILE$	String	*Ambient input file*
AMBOPT$	String	*Option to read in ambient or not*
AVEAMB	Single	*Current 24-hour average ambient exposure*
AVEEXP	Single	*Current 24-hour average microenvironmental exposure*
CALCMODE$	String	*Current Calculation Method (e.g., SCEM or MICR)*

CALCOPT$	String	*Option for "all", "N", or "detailed" calculation*
CURRENTACT%	Integer	*Current activity*
CURRENTLOC%	Integer	*Current locaiton*
CURRENTSMOK%	Integer	*Current smoking presence (0 = no smoker present)*
DATE	Single	*Current date in Julian format*
EXCHANGE()	Array Single	*Distribution parameters for air exchanges*
EXPFILE$	String	*Exposure profile output file*
FOOTAGE()	Array Single	*Distribution parameters for house footages*
GROUPOPT$	String	*Opton to regroup or not regroup locations into LOCAT() codes*
HOURFILE$	String	*Hourly exposure summary output file*
INFILE$	String	*Activity pattern input file*
LASTPID&	Long	*Last Personal Identification Number (set to PID& after first diary line is read)*
LOCAT() AS LOCCODES		*Array for location information (see type declaration above)*
MAXEXP	Single	*Current maximum minutely microenvironmental exposure*
NSMRATE()	Array Single	*Distribution parameters for smoking rate*
NSOURCE()	Array Single	*Distribution parameters for source strength*
NUMBER%	Integer	*Number of people chosen to process*
NUMGROUPS%	Integer	*Number of regrouped location categories; see LOCAT() dimension*
NUMROOMS()	Array Single	*Distribution parameters for number of rooms*
NVEHEXCHC()	Array Single	*Distribution parameters for vehicle exchange rate with windows closed*
NVEHEXCHO()	Array Single	*Distribution parameters for vehicle exchange rate with windows open*
NVEHVOL()	Array Single	*Distribution parameters for vehicle volumes*

OMITOUT	Single	*Threshold for ommision of outliers*
PATH$	String	*Path for BASIC modules (used during compilation)*
PEOPLE%	Integer	*Number of people processed*
PERSONDATA AS DEMOG		*Current demographic information*
PID&	Long	*Personal Identification Number (PID #)*
POPFILE$	String	*Population exposure output file*
RECPERSON&	Long	*Current number of records read in from INFILE$*
RECTOTAL&	Long	*Total number of records read in from INFILE$*
RT1$	Single	*Run Time option 1*
RT10$	String	*Run Time option 10*
RT2$	String	*Run Time option 2*
RT3$	String	*Run Time option 3*
RT4$	String	*Run Time option 4*
RT5$	String	*Run Time option 5*
RT6$	Single	*Run Time option 6*
RT7$	String	*Run Time option 7*
RT8$	String	*Run Time option 8*
RT9$	String	*Run Time option 9*
SCEMFILE$	String	*SCEM parameter output file*
TALLYFILE$	String	*Exposure time tally output file*
TIMES%	Integer	*Times UPDATESCREEN subprogram has been called during a calculation*
TOTMAX	Single	*Current 24-hour average total maximum hourly exposure*

Single = Single Precision Real
Long = Long Integer
Blank types are custom-typed variables
"Current" means for current person

Table 11. Global constants declared in THEMDECS.BI for THEMBASIC.BAS

Constant	Description
	Colors for Screen Output
Back = 9	blue for background
Inst = 15	white for instructions
Lin = 13	magenta for separating lines
Quit = 14	yellow for quit instruction
SubT = 9	blue for subtitles
Text = 11	cyan for text
Title = 10	light green for titles

Adding a New *M*-Subprogram

Adding a new *M*-subprogram to THEM for calculating micronenvironmental exposures requires creating a new BASIC subprogram, changing a logic structure, changing data structures, adding code to read in new model parameters, and adding parameter frequency distributions to THEMDIST.DAT (Table 12). The new subprogram can be anything from a simple constant value model to a complex mass balance algorithm.

Table 12. Checklist for Adding a New Microenvironmental Exposure Model to THEM

1. Write a QuickBASIC subprogram that inputs the 1440-minute long LOCATION%(), ACTIVITY%(), and SMOKERS%() arrays and assigns exposures for every minute.
2. Change logic statement in THEMMAIN (RSPFill subprogram) to branch to a new subprogram when the calculation option matches
3. Declare new subprogram and global parameter distribution arrays (useCOMMON SHARED statement) in THEMDECS.BI include file for THEMMAIN.BAS.
4. Modify ReadDistParams QuickBASIC subprogram to read in appropriate model parameter distributions from the THEMDIST.DAT text file into parameter distribution arrays
5. Dimension parameter distribution arrays in THEMMAIN.BAS program module
6. Enter model parameter frequency distributions into THEMDIST.DAT

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Appendix A: Location Data (THEMLOC.DAT)

```
1  This is the file: THEMLOC.DAT  It contains the possible locations
2  in which people are present for the THEM model as tabulated in the
3  California Activity Pattern (CAP) database.
4
5
6  The number of the location is on the left, followed by the location
7  name.  Next are the location codes in CAP that are being regrouped into
8  these new locations.  Calculation method is listed last.
9  For Example:        old CAP codes regrouped into this one
10  # old codes-----v |-------|------------|
11          _1_Home_9_1_2_3_4_34_24_56_67_78_SCEM_
12 new code #^ ^^^^location name             ^^^Calculation Method
13 The different segments of information are separated by the "_" character.
14 The first number in the data file is the number of new groups.
15========================== Beginning of Data ==============================
6
_1_AT HOME_13_1_2_3_4_5_6_7_8_9_12_13_32_99_SCEM_
_2_OFFICE-FACTORY_3_21_22_38_SCEM_
_3_OTHER INDOORS_12_23_24_25_26_27_30_31_33_35_36_37_39_SCEM_
_4_BAR, RESTAURANT_2_28_29_SCEM_
_5_OUTDOORS_7_10_11_34_40_53_54_59_SCEM_
_6_VEHICLE_8_51_52_55_56_57_58_60_61_SCEM_
```

Appendix B: Distribution Data (THEMDIST.DAT)

```
1  This the the file: THEMDIST.DAT.  It is a data file for use with the
2  Total Human Exposure Model (THEM) group of programs that contains all
3  the parameters for distributions of data.  The user may change any of
4  these parameters as he/she wishes keeping in mind the data labeled as
5  REAL was obtained from actual surveys.  See the THEM manual for details.
6  !!!! DO NOT CHANGE THE NUMBER OR FORMAT OF THE DATA SETS !!!!
7  Explanation of Data Format: Lists of >1 paired numbers consist of
8  univariate cumulative distributions with the ranges first and the
9  proportion below that number next.  99,99 signifies the end of data.
10 Lists with 1 pair of numbers are the mean and standard deviation for
11 NORMAL or LOGNORMAL distributions as labeled.  Distributions of model
12 parameters are listed first with distrbutions for microenvironmental
13 concentrations listed towards the end of the file.
14 ====================== Beginning of Data ============================
REAL-------------Footage, square feet
200, 0.0000001
400, 0.014
599, 0.040
999, 0.14
1499, 0.488
1999, 0.782
2699, 0.937
3499, 0.980
5000, 1.000
99, 99
REAL-------------Air Exchange, air changes per hour (ach)
0.31, 0.05
0.76, 0.25
2.12, 0.40
4.15, 0.75
10.59, 0.95
15.00, 1.000
99, 99
REAL-------------Rooms in a House
1, 0.002
2, 0.007
3, 0.033
4, 0.132
5, 0.396
6, 0.680
7, 0.840
8, 0.933
9, 0.969
10, 0.986
15, 1.000
99, 99
NORMAL-----------Vehicle Volumes, cubic feet
150, 20
NORMAL-----------Vehicle Air Exchange Rate (Windows Open), ach
75, 20
NORMAL-----------Vehicle Air Exchange Rate (Windows Closed), ach
5, 1.1
NORMAL-----------Source Strength, ug/cigarette
12100, 1000
NORMAL-----------Smoking Rate, cigarettes/hour
2.0, 0.3
REAL-------------Home Microenvironmental Concentrations, ug/m3
60, 0.5
107, 1.000
99,99
```

```
REAL-------------Bar-Restaurant Microenvironmental Concentrations, ug/m3
308, 1.000
99,99
REAL-------------Office-Factory Microenvironmental Concentrations, ug/m3
250, 1.000
99,99
REAL-------------Other Indoor Microenvironmental Concentrations, ug/m3
132, 1.000
99,99
REAL-------------Outdoor Concentrations (not including ambient), ug/m3
0, 1.000
99,99
REAL-------------Vehicle Microenvironmental Concentrations, ug/m3
450, 1.000
99,99
```

Appendix C: THEMDECS.BI Source Code Listing

```
'****************************************
'*  THEMDECS.BI
'*
'*  BASIC INCLUDE file containing all
'*  sub program declarations and global
'*  type and variable declarations for
'*  main THEM program.
'*
'*  Main Module: THEMMAIN.BAS
'****************************************
DECLARE SUB GraphProfile (LOCATION%(), SMOKERS%(), RSP!())
DECLARE SUB AmbientArray (AMBIENT!(), date2!, date1!, AMBDATA() AS STRING * 78)
DECLARE SUB ReadAmbient ()
DECLARE SUB AmbientFile (AMBIENT!(), date2!, date1!, AMBFILE$)
DECLARE SUB InitializeHead ()
DECLARE SUB GoToPerson (N%)
DECLARE SUB SetUpScreen ()
DECLARE SUB SaveWriteActivity (LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP!(), AMBIENT!())
DECLARE SUB SaveWriteExposure (LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP!(), AMBIENT!())
DECLARE SUB PrintEpisode (HEAD$)
DECLARE SUB RSPFill (LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP!())
DECLARE FUNCTION SCEMExp! (LOCATION%)
DECLARE SUB ReadNextPerson (LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP(), AMBIENT())
DECLARE SUB ExcludeMenu ()
DECLARE SUB AssignMenu ()
DECLARE SUB AddSummary ()
DECLARE SUB Initialize ()
DECLARE SUB ReadDistParams ()
DECLARE SUB SaveSCEM (HEAD$)
DECLARE SUB CalculatePerson (LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP(), AMBIENT())
DECLARE SUB ProcessPerson ()
DECLARE SUB StorePerson (AMBIENT!(), RSP!())
DECLARE SUB AmbExp (AMBIENT!(), date2!, date1!, AMBFILE$)
DECLARE SUB Calender (date1!, M!, d!, Y!)
DECLARE SUB ClearProfile (N%, PROFILE%())
DECLARE SUB ClearVector (N%, VECTOR!())
DECLARE FUNCTION MicroExp (LOCATION%, ACTIVITY%, SMOKERS%)
DECLARE SUB Diary (WH%, LOCATION%(), SMOKERS%(), ACTIVITY%())
DECLARE SUB EnterDist (VECTOR!())
DECLARE SUB EnterLNorm (VECTOR!())
DECLARE SUB Fill (PROFILE%(), N%)
DECLARE SUB FindPersonID (PID&, FILENAME$)
DECLARE SUB GroupMenu ()
DECLARE SUB RegroupLoc (WH%)
DECLARE SUB RetrieveOptions ()
DECLARE SUB SaveOptions ()
DECLARE SUB MainMenu (CHOICE$)
DECLARE SUB DoTitle ()
DECLARE SUB OptionsMenu ()
DECLARE SUB PrintOutOptions ()
DECLARE SUB ShowLocations ()
DECLARE SUB GetLoc ()
DECLARE SUB RestartCalc ()
DECLARE SUB ShowConstExp ()
DECLARE SUB ShowGroupLoc ()
DECLARE SUB ShowParamsMenu ()
DECLARE SUB UpdateScreen (STATUS$)
DECLARE SUB WriteDist (VECTOR!())
DECLARE SUB PrintHourlySum (HEAD$, N%, RSP!(), AMBIENT!())
DECLARE SUB PrintProfile (HEADER$, VECTOR%())
DECLARE SUB PrintVector (HEADER$, VECTOR!())
DECLARE SUB SaveHourlySum (RSP!(), AMBIENT!())
DECLARE SUB SaveVector (FILENAME$, HEADING$, VECTOR!(), N%)
DECLARE SUB WriteHourlySum (RSP!(), AMBIENT!())
DECLARE SUB WriteProfile (HEADING$, VECTOR%())
DECLARE SUB WriteVector (HEADING$, VECTOR!())
DECLARE SUB SaveProfile (FILENAME$, HEADING$, VECTOR%(), N%)
'
'****************
'**   TYPES   ***
'****************************************************************
'
'Type for SCEM parameters
'
TYPE SMPARAMS
```

```
    ACH AS SINGLE       'air exchange rate ach
    VOLUME AS SINGLE    'volume m3
    SMRATE AS SINGLE    'smoking rate #/min
    SOURCE AS SINGLE    'source stregth ug/min
    SMLOC AS SINGLE     'location code
    AVECONC AS SINGLE   'average concentration ug/m3
    NUMROOMS AS SINGLE  'number of rooms in house
END TYPE
'
'Type for location codes
'
TYPE LOCCODES
    CODE AS INTEGER              'new code number
    NAME AS STRING * 15          'name of new code
    REGROUP(1 TO 100) AS INTEGER 'regrouped codes
    NGROUP AS INTEGER            'number of regrouped codes
    ETSDIST(2, 25) AS SINGLE     'ETS exposure distribution for location
    EXCLUDE AS STRING * 1        'X = zero contrib. from this loc; O = include
    SAMPLE AS SINGLE             'exposure sampled from distribution
    METHOD AS STRING * 4         'SCEM OR MICR
    TALLY AS INTEGER             'number of minutes exposed in each location
END TYPE
'
'Type for demographic information
'
TYPE DEMOG
    AGE AS INTEGER
    SEX AS INTEGER
    PID AS LONG
    EXPOS AS INTEGER
END TYPE
'
'omit outliers over
COMMON SHARED OMITOUT
'
' General Statistical Routines are in the GENSTAT.BAS module
' included in THEMMAIN.BAS.  Histograms are created using the
' CALCHIST.BAS program which includes the THEMSTAT.BAS module.
'
'   **DATA FOR CREATING EXPOSURE HISTOGRAMS**
'.....................................................
COMMON SHARED /ExposureData/ MAXEXP, AVEEXP, AVEAMB, TOTMAX
'.....................................................
'         Array for Fairley ambient data
'.....................................................
COMMON SHARED AMBDATA() AS STRING * 78
'.....................................................
'
'file names including paths
COMMON SHARED /pop/ POPFILE$ 'file for population exposure data
COMMON SHARED /fil1/ INFILE$, AMBFILE$, HOURFILE$, SCEMFILE$
COMMON SHARED /fil2/ ACTFILE$, LOCFILE$, SMOKFILE$, EXPFILE$
COMMON SHARED /fil3/ TALLYFILE$  'file for tally of "exp. time" in each loc.
'
'path for options, input & include files; used during program compilation
COMMON SHARED /pat/ PATH$
'
'***************************************************************************
'
COMMON SHARED TIMES%  'Times there has been a call to UpdateScreen
'
COMMON SHARED /SCEM/ SCEM AS SMPARAMS           'Parameters for SCEM Model
COMMON SHARED /LOCATIONS/ LOCAT() AS LOCCODES   'Parameters for Location Codes
COMMON SHARED /DEMOGRAPH/ PERSONDATA AS DEMOG   'Demographic data
COMMON SHARED /NUMS/ NUMGROUPS%                 'Number of reduced locations
COMMON SHARED CURRENTLOC%, CURRENTACT%, CURRENTSMOK% 'Current location, activity, smoker?
'
COMMON SHARED /ALOOP/ ALLSTOP%              'Control Variable for "All"-type calculation
'
'personal diary information
COMMON SHARED /a/ PID&, LASTPID&, PEOPLE%, NUMBER%, RECPERSON&, RECTOTAL&
COMMON SHARED /b/ DATE, CALCOPT$, CALCMODE$, AMBOPT$, GROUPOPT$
COMMON SHARED /c/ RT1$, RT2$, RT3$, RT4$, RT5$, RT6$, RT7$, RT8$, RT9$, RT10$
COMMON SHARED /d/ ID, a.y, tbeg, tend, etim, ctim, where, DSMOKE
COMMON SHARED /e/ act, dirm, dird, diry, dirwkday
'
'
'distribution arrays
COMMON SHARED /dist/ FOOTAGE(), EXCHANGE(), NUMROOMS()
'
'normal mean and stdev arrays
```

```
COMMON SHARED /dist2/ NVEHEXCHO(), NVEHEXCHC(), NVEHVOL(), NSMRATE(), NSOURCE()
'
'"personal data" fields:
COMMON SHARED /f/ RN01&, RSEL&, YSEL&, TPAC&, PRFX&, CLST&, STUM&, ACDT&, HHA&, HHAT&, HOUS&, PARK&, PRK2&,
WKJB&, WKHR&, VWHR&, NJOB&, WP1&, WP2&, WP3&, WP4&, WP5&, WP6&
COMMON SHARED /g/ SMOK&, SMKY&, SMK2&, SMY2&, CLC4&, CLC6&, PGAR&, PGYS&, PGAS&, GSTV&, NSTV&, MS1&, MSTM&,
MS2&, GSPR&, GSTM&, PLOT&, HTYS&, HTFL&, HEAT&, OPE&, OPN1&, OPN2&, FAN1&, FAN2&, AIRC&, ACTP&, GLUE&,
PNT1&, PNT2&, SOLV&, PEST&
COMMON SHARED /h/ PST2&, SOAP&, OCLN&, AERO&, SHWR&, BATH&, MOTH&, DEOD&, RMFR&, AGE&, EDUC&, GDGR&, MRTL&,
ZIP&, CNTY&, AREA&, HHT&, BG15&, BG16&, BG17&, RSEX&, INCM&, INCA&, INCB&, INCC&, INCD&, INCE&, INCF&,
ISUM&, HHTT&, YTJB&
COMMON SHARED /i/ YWHR&, YVHR&, YNJB&, YWP1&, YWP2&, YWP3&, YWP4&, YWP5&, YWP6&, YSTU&, YSMK&, YSMY&, YSM2&,
YSY2&, YCC6&, YCC8&, YPGR&, YPGY&, YPGS&, YSTV&, YNST&, YMS1&, YMSM&, YMS2&, YGSP&, YGTM&, YPLT&, YGLU&,
YPT1&, YPT2&, YSLV&, YPST&, YPS2&
COMMON SHARED /j/ YSP&, YCLN&, YARO&, YSHR&, YBTH&, YAGE&, YEDU&, YSEX&, YCDT&, AOUT&, YOUT&, TTIM&, INUM&,
TCNT&, RCNT&, RANS&, ANYO&, CSUM&, ANUM&, ZTST&, ADIFF&, YDIFF&, NPHONE&, YINTV&, dirmm&, dirdd&, diryy&
COMMON SHARED /k/ ADWKDAY&, CMPMM&, CMPDD&, CMPYY&, ACWKDAY&, OCC&, YDIRMM&, YDIRDD&, YDIRYY&, YDWKDAY&,
YCMPMM&, YCMPDD&, YCMPYY&, YCWKDAY&, YOCC&, SMOKE&, YSMOKE&, SAMPWT, TIMEWT, YSAMPWT, YTIMEWT
'
'Histogram bar widths
COMMON SHARED /bwa/ BarWidthAve  'Bar width for Average Indoor
COMMON SHARED /bwa2/ BarWidthAmb  'Bar width for ambient exp.
COMMON SHARED /bwm/ BarWidthMax  'Bar width for Maximum exp.
COMMON SHARED /hop/ HOPT%        'Specify Barwidth or Start, Stop, # Bars
'
'Screen foreground and back ground colors
CONST Back = 9       'blue
CONST Title = 10     'light green
CONST Text = 11      'cyan
CONST Lin = 13       'magenta
CONST Inst = 15      'white
CONST Quit = 14      'yellow
CONST SubT = 9       'blue
'
'************************************************************************
```

Appendix D: THEMMAIN.BAS Source Code Listing

```
'*************************************************
'*                 THEMMAIN.BAS                  *
'*                 "Main Module"                 *
'**                    For                      **
'***         Total Human Exposure Model          ***
'***                                             ***
'***                  (THEM)                     ***
'***                                             ***
'***     -using California Activity Pattern      ***
'***           (CAP) data from the Air           ***
'***           Resources Board (ARB)             ***
'**      -and data from real RSP exposure         **
'*             measurements                       *
'*                                                *
'*************************************************
'
'Written in Microsoft (R) QuickBASIC Extended v7.1
'
'Development Funded by the Tobacco Related Disease Research
'Program (TRDRP) of the State of California, grant no. ?????
'
'Other Modules: THEMIO.BAS, THEMSTAT.BAS, THEMGRX.BAS
'Include Files: THEMIO.BI, THEMSTAT.BI, THEMGRX.BI, THEMDECS.BI
'Data Files: THEM.OPT, THEMDIST.DAT, THEMLOC.DAT
'-----------------------------------------------------------------------------
'THEMDECS.BI ====== All procedure/type declarations and
'                   common shared variables/constants for main program
'THEMSTAT.BAS ===== Statistical Routines
'THEMIO.BAS ======= Input/Output Routines
'THEMGRX.BAS ====== Invocation of QuickBASIC Presentation Graphics Toolbox
'*********.BI  ==== QuickBASIC INCLUDE files for each module's declarations
'-----------------------------------------------------------------------------
 '
'Last Modified: 10/19/93  nk
'
'Programming History & Personnel:
'-----------------------------------------------------------------------------
'Program written by Wayne Ott, Stanford Unversity, beginning July 1991
'Program was extended by Elena Tracy and Wayne Ott, beginning Fegruary 1993
'Program rewritten by Neil Klepeis, beginning August 1993
'Program modularized, menu driven 9/16/93  nk
'Program modularized into: THEMMAIN, THEMIO, THEMSTAT, THEMGRX  nk
'All subsequent modifications: nk
'-----------------------------------------------------------------------------
'
'Description of Program:
'-----------------------------------------------------------------------
'** The current form of the program is as follows: ***
'
'1. Program reads the California Activity Pattern (CAP) data file
'2. Program generates "uniform diaries" 1440 min. long from actual diaries
'3. Program creates location & smoker-present vectors for each person
'     automatically regrouping locations into six subgroups
'4. Program assigns CONSTANT EXPOSURES for each min. for each person
'5. OR uses the SCEM Model to assign ETS exposures.(see SCEM2 sub for details)
'5. Program calculates 1440 minutes of exposure per person
'6. Program has user-definable run-time options and default settings.
'     These are accessbile via the user-accessible menu system
'7. Program displays,prints,saves summaries and histograms of the group
'     of people analyzed      8/94 nk
'8. a.Options, b.Distribution Parameters, c.Regrouped Location Codes and
'    Constant Microenvironmental RSP exposures for ETS are user-definable
'    through external text files: THEM.OPT, THEMDIST.DAT, THEMLOC.DAT,
'    respectively.     10/94 nk
'9. Saves and produces exposure histograms for different demographic groups:
'     age, sex, education, employment status, marital status, housing type.
'10. Separates exposed people from unexposed people.  1/94 nk
'11. Program separated in THEM and THEMHIST programs.  THEM only determines
'    24-hour exposures and hourly maximums for each person and saves them to
'    a list.  THEM acts like a needle with data flowing through it like a
'    thread; the summary arrays are NOT stored in the computer but on file.
'    THEMHIST take the summary file and calculates histograms from it: exposed
'    vs. unexposed and all demographics.  2/94 nk
'
'-----------------------------------------------------------------------------
'
' iiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii
```

```
' iiiiii   INCLUDE Files containing all        iiiii
' iiiiii   sub program/function declarations,  iiiii
' iiiiii   types and shared variables          iiiii
' iiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii
'
' $INCLUDE: 'd:\them\basic\THEMDECS.BI'
'
' $INCLUDE: 'd:\them\basic\GENIO.BI'
'
' $INCLUDE: 'd:\THEM\BASIC\GENSTAT.BI'
'
' iiiiiiiiii End of Include File Section iiiiiiiiiii
' iiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii
' iiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii
'
'************************************************************************
'*****************     Dimension Arrays and Variables    ******************
'************************************************************************
'COMMON SHARED HIST AS HISTOGRAM     'Parameters for Histograms
'COMMON SHARED PERSONDATA AS DEMOG   'variable for all demographic data
'Note: other "COMMON SHARED" statements are in THEMDECS.BAS
' The "COMMON SHARED HIST AS HISTOGRAM" statement is in
' all modules that call the CalculateHist routine.  This
' variable is passed to the CalculateHist routine but the type-
' declaration is in the THEMSTAT.BAS module.
'
'The following variables contain data compiled for each person,
'saved in a file and used to create statistics on the whole pool
'of people analyzed.
'
'MAXEXP:  MAXIMUM MINUTELY EXPOSURE FOR EACH PERSON OVER 1 DAY
'AVEEXP:  AVERAGE 24-HOUR MICR. EXPOSURE FOR EACH PERSON OVER 1 DAY
'TOTMAX:  TOTAL HOURLY MAXIMUM EXPOSURE FOR EACH PERSON OVER 1 DAY
'AVEAMB:  AVERAGE AMBIENT EXPOSURE FOR EACH PERSON OVER 1 DAY
'Demographics variables are defined in THEMDECS.BI
'PERSONDATA = CODES FOR DEMOGRAPHIC GROUP:  age,sex,ed.,emp.,mar,hous.
'
'*********************************************************************
'note: THEM calculations will produce exposure statistics for everyone. This
'data can then be subdivided into demographic groups and/or the exposed group.
'Demographic data for each person is in array PERSONDATA and exposed vs.
'non-exposed data is simply obtained from the exposures themselves:
'0.0 ug/m3 = unexposed.
'*********************************************************************
'
'Arrays for distribution data to be randomly sampled for use as parameters
'    in sub models
'
DIM FOOTAGE(2, 25)  'dist. of sq. footages for a house -hunds. of sq. ft.-
DIM EXCHANGE(2, 25) 'dist. of air exchange rates-ach- for a house
'DIM VEHEXCH(2, 25)  'dist. of vehicle air exchange rate-ach
'DIM SMRATE(2, 25)   'dist. of smoking rates-cig. per hour
'DIM VEHVOL(2, 25)   'dist. of vehicle volumes--square feet
DIM NUMROOMS(2, 25) 'dist. of number of rooms in a house
'DIM SOURCE(2, 25)   'dist. of source strengths (ug/cigarette)
'normal mean and stdev arrays
DIM NVEHEXCHO(2), NVEHEXCHC(2), NVEHVOL(2) 'vehicle ach win cl;win op, vehicle volume
DIM NSMRATE(2), NSOURCE(2) 'smoking rate, source strength
'
'array to hold location codes and RSP levels corresp. to locations (ug/m3)
'LOCAT is "redim'ed" in GetLoc subprogram
NUMGROUPS% = 6: CURRENTLOC% = 1: LAST% = 2
'REDIM LOCAT(1 TO NUMGROUPS%) AS LOCCODES
'
'omit outliers in averages and st. dev.
OMITOUT = 1E+10
'
'DIM AMBDATA(731) AS STRING * 78   'array for fairley ambient data (unused)
'
'PRINT FRE(AMBDATA(1))
'SLEEP

'************************************************************************
'-----------------------End Of Array Dimensioning--------------------------
'************************************************************************
'
'++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
'$$$$$$$$$$$$$$   Pre-Title-Screen Initializing Routines  $$$$$$$$$$$$$$$$
'########################################################################
'
CLS
```

```
'
Initialize      'Zeros pointer, constant exp. levels, person id, Path
'
RetrieveOptions 'read THEM.OPT, the file containing options
'
GetLoc          'get new location codes, names, old codes, ETS exposure for
'                each new group
'
ReadDistParams  'read in cumulative distributions/normal & lnormal params
'
'ReadAmbient     'read ambient data into array AMBDATA$()
'
'** If there is an error reading the options file; and the error is ignored
'** then internal defaults are set:
'
IF INFILE$ = "" THEN GOSUB SetDefaults
'
DoTitle                         'Program Title Displayed
'
OpenFile INFILE$, 1, 1          'Opens CAP Input data file for input
'
'ON ERROR GOTO ProcessErrors:    'Turns error checking on
'
'** Set user-defined key ESC:  used to exit calculation loops
'
KEY 15, CHR$(0) + CHR$(1)        'assigns ESC key to #15
'
'^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
'!!!!!!!!!!!!!!!!!!!  End of Initialization Routines  !!!!!!!!!!!!!!!!!!!
'?????????????????????????????????????????????????????????????????????????????
'
'&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&
'************************* ENTERING MAIN LOOP ******************************
'==========================================================================
'
   CONT% = 0
   WHILE CONT% = 0
      MainMenu CHOICE$     'Displays main menu
      CLS
      SELECT CASE CHOICE$  'Processes Choice from main menu
        CASE "O", "o":     'Passes Control to Options Menu
                OptionsMenu
        CASE "d", "D":
                IF PEOPLE% = 0 OR POP$ = "" THEN InitializeHead
                'PRINT "Detailed Calculation of one person..."
                CALCMODE$ = "Detailed"
                NUMBER% = 1
                SetUpScreen
                CALL ProcessPerson
                AddSummary
                CALL UpdateScreen("Press Any Key to Return to Main Menu...")
                SLEEP
        CASE "N", "n":
                PRINT : INPUT "Enter number of people: ", NUMBER%
                CALCMODE$ = "N"
                PRINT
                PRINT "Previous Number of People Calculated: "; PEOPLE%
                PRINT "Number of People After This Calculation: "; NUMBER% + PEOPLE%
                PRINT
                PRINT "Press any key to continue...": SLEEP
                IF PEOPLE% = 0 OR POPFILE$ = "" THEN InitializeHead
                SetUpScreen
                KEY(15) ON
                ON KEY(15) GOSUB ExitN
                k = 1
                WHILE k <= NUMBER%
                   CALL ProcessPerson
                   k = k + 1
contN:
                WEND
                KEY(15) OFF
                AddSummary
                CALL UpdateScreen("Press Any Key to Return to Main Menu...")
                SLEEP
        CASE "a", "A":
                ANS$ = GetAKey("Press <RET> to do all people or <ESC> to cancel...")
                IF ANS$ = CHR$(13) THEN
                   CALCMODE$ = "All"
                   IF PEOPLE% = 0 OR POPFILE$ = "" THEN InitializeHead
                   SetUpScreen
                   KEY(15) ON
```

```
                   ON KEY(15) GOSUB ExitAll:
                   ALLSTOP% = 0
                   WHILE ALLSTOP% = 0
                       CALL ProcessPerson
contA:
                   WEND
                   KEY(15) OFF
                   AddSummary
                   CALL UpdateScreen("Press Any Key to Return to Main Menu...")
                   SLEEP
                END IF
        CASE "v", "V": LookAtFile POPFILE$
        CASE "e", "E":
                CLS
                PRINT "This will erase the exposure data file: " + POPFILE$
                PRINT "The exposure file is normally appended between all THEM calculations."
                ANS$ = GetAKey("Press <RET> to ERASE or <ESC> to CANCEL...")
                IF ANS$ = CHR$(13) THEN KILL POPFILE$
        CASE "r", "R":   'Restarts Calculation by Initializing files pointers
                RestartCalc
        CASE "g", "G":
                Initialize
                INPUT "Enter the Person Number:"; N%
                GoToPerson N%
        CASE "f", "F":
                Initialize
                INPUT "Enter the PID: "; PID&
                FindPersonID PID&, INFILE$
        CASE "c", "C": PrintOutOptions
        CASE "s", "S": ShowParamsMenu
        CASE "l", "L":
                PRINT "This will restart calc. at beginning of file."
                PRINT "Press ESC to CANCEL, RET to continue..."
                ANS$ = GetAKey("")
                IF ANS$ = CHR$(13) THEN
                    CLOSE #1
                    LookAtFile INFILE$
                    OpenFile INFILE$, 1, 1
                END IF
        CASE "`": CLS
                 INPUT "Name of file: ", FIL$
                 LookAtFile FIL$
        CASE "q", "Q": CONT% = 1
        CASE ELSE
      END SELECT
      CLS
  WEND
  '
  CLOSE #1                     'close activity input file
                               'others opened & closed in sub prog.
  SaveOptions                  'Save Options to file, THEM.OPT
  '
  SCREEN 0: COLOR 7, 0: CLS    'Restore Screen to Text (0), white foreground
'
END
'
'((((((((((((((((((((||||||||||||||||||||||||||||||))))))))))))))))))))))))))
'******************** END OF MAIN LOOP: QUIT PROGRAM ***********************'
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'
'---------------------------------------------------------------------------
'** Subroutines to handle interupt of
'** N and All Calculations after ESC pressed
'---------------------------------------------------------------------------
ExitN:
  k = NUMBER% + 1
  UpdateScreen "CANCEL on Person #" + STR$(PEOPLE%) + ".  Press any key...                "
  SLEEP
  CLOSE #2       'all files opened in subs are #2; close if interupted
  PEOPLE% = PEOPLE% - 1  'back to last person before interupt
  COLOR 7
RETURN contN:
'
ExitAll:
  ALLSTOP% = 1
  UpdateScreen "CANCEL on Person #" + STR$(PEOPLE%) + ".  Press any key...                  "
  SLEEP
  CLOSE #2               'all files in subs are #2; close if interrupted
  PEOPLE% = PEOPLE% - 1  'go to last person before interrupt
  COLOR 7
RETURN contA:
```

```
'------------------------------------------------------------------------------
'------------------------------------------------------------------------------
'
'*****************************************************
'-------------------MAIN SUB ROUTINES---------------------
'
'  -SetDefaults      -ProcessErrors       -ReadDistParams
'
'_____________________________________________________
'
SetDefaults:
        CLS : BEEP
        PRINT "Errors in reading options file or null INPUT file name"
        PRINT "both require the setting of internal default parameters.": PRINT
        PRINT "Press any key to assign internal defaults.": SLEEP
        'activity pattern data file
        INFILE$ = "d:\californ\BAY.DAT"
        'ambient level data file
        AMBFILE$ = "c:\californ\PART.DAT"
        'output file for activity codes; if 'none' then no codes written
        ACTFILE$ = ""
        'output file for exposure vectors; if 'none' then no vectors written
        EXPFILE$ = ""
        'output file for hourly summaries of each person
        HOURFILE$ = ""
        'output file for SCEM parameters
        SCEMFILE$ = ""
        'regrouping of locations
        GROUPOPT$ = "Yes"
        '
        '** CALCULATION OPTIONS **
        '
        CALCOPT$ = "CONST"  'use SCEM routine or CONST RSP values
        AMBOPT$ = "No"  'reading in of ambient data
        '
        '** Run time screen options
        '
        RT1$ = "No"   'print out personal data to screen
        RT2$ = "No"   'print out location/activity/smoking profiles to screen
        RT3$ = "No"   'print out exposure vectors to screen
        RT4$ = "No"   'pause between person calculations
        RT5$ = "No"   'print out hourly summary for each person
        '
        '** printer options
        '
        RT6$ = "No"   'print loc/act/smok profiles to printer
        RT7$ = "No"   'print indoor/ambient exposures to printer
        RT8$ = "No"   'print hourly summary of each person to printer
        '
        RT9$ = "No"  'pause between SCEM/CONST parameter changes
        RT10$ = "No" 'print SCEM parameters out to line printer
        '
RETURN
'
'
ProcessErrors:
        BEEP
        LOCATE 24, 1
        COLOR 14     'yellow error message
        SELECT CASE ERR
            CASE 6: PRINT "OVERFLOW ERROR.";
            CASE 7: PRINT "OUT OF MEMORY ERROR.";
            CASE 52: PRINT "FILENAME ERROR.";
            CASE 53: PRINT "FILE NOT FOUND.";
            CASE 54, 55: PRINT "FILE ACCESS ERROR.";
            CASE 57: PRINT "CAN'T ACCESS FILE.";
            CASE 58: PRINT "FILE EXISTS ERROR.";
            CASE 61: PRINT "DISK IS FULL.";
            CASE 68: PRINT "CAN'T ACCESS DEVICE.";
            CASE 71: PRINT "DISK NOT READY.";
            CASE 72: PRINT "DISK ERROR.";
            CASE 76: PRINT "FILE PATH NOT FOUND.";
            CASE 62: PRINT "INPUT PAST END OF FILE.";
            CASE ELSE:
               PRINT "AN ERROR HAS OCCURRED.";
            END SELECT
        PRINT "  Press any key to continue..."; : SLEEP
        COLOR 15    'back to high intensity white
RESUME NEXT

SUB AddSummary
```

```
'
'** subprogram to add input filename
'   to bottom of population exposure file: POPFILE$
'   and to the bottom of TALLYFILE$ if not NULL
'
        OpenFile POPFILE$, 2, 3    'open file #2 for append
        '
        EXCL$ = ""
        METH$ = ""
        FOR I = 1 TO NUMGROUPS%
            EXCL$ = EXCL$ + LOCAT(I).EXCLUDE
            METH$ = METH$ + LOCAT(I).METHOD + "."
        NEXT I
        '
        PRINT #2, "(" + INFILE$ + ", " + EXCL$ + ", " + METH$ + ", " + CALCMODE$ + ")"
        '
        CLOSE #2
        '
        IF TALLYFILE$ <> "" THEN
           OpenFile TALLYFILE$, 2, 3   'open file #2 for append
           PRINT #2, "(" + INFILE$ + ", " + EXCL$ + ", " + METH$ + ", " + CALCMODE$ + ")"
           CLOSE #2
        END IF
        '
END SUB

SUB AmbientArray (AMBIENT(), date2, date1, AMBDATA() AS STRING * 78)
'
'**  sub program to get ambient data for current day from array AMBDATA$()
'
    CONST CONV = .6     'Conversion factor from PM-10 to PM-3.5?
    '
    FOR X = 1 TO 731
        L$ = AMBDATA$(X)      'assign to next string array
        D$ = LEFT$(L$, 5)
        f = VAL(D$)
        FOR I = 1 TO 24
            v$ = MID$(L$, (I * 3) + 3, 3)
            v = VAL(v$)
            AMBIENT(I) = v * CONV
        NEXT I
        IF f = date1 THEN
'            date2 = F
            GOTO 12:
        END IF
    NEXT X
12 :
    ' FOR i = 1 TO 24
    '     FOR j = (i - 1) * 60 + 1 TO i * 60
    '          RSP(j) = R1(i)
    '     NEXT j
    ' NEXT i
    '
END SUB

SUB AmbientFile (AMBIENT(), date2, date1, AMBFILE$)
'
'**  sub program to get ambient data for current day from file AMBFILE$
'
    CONST CONV = .6     'Conversion factor from PM-10 to PM-3.5?
    '
    CALL OpenFile(AMBFILE$, 2, 1)   'open as #2 for input
    '
    FOR X = 1 TO 731
        INPUT #2, L$
        D$ = LEFT$(L$, 5)
        f = VAL(D$)
        FOR I = 1 TO 24
            v$ = MID$(L$, (I * 3) + 3, 3)
            v = VAL(v$)
            AMBIENT(I) = v * CONV
        NEXT I
        IF f = date1 THEN
'            date2 = F
            GOTO 11:
        END IF
    NEXT X
11 :
    ' FOR i = 1 TO 24
    '     FOR j = (i - 1) * 60 + 1 TO i * 60
    '          RSP(j) = R1(i)
```

```
    '     NEXT j
    ' NEXT i
    '
    CLOSE #2
'
END SUB

SUB AssignMenu
'
'** subprogram to assign method of calculating exposure: SCEM or
'   sampling from real microenvironmental data distributions
'
    OPT% = 0
    CLS
    WHILE OPT% = 0
        PlaceText "ASSIGN EXPOSURE CALCULATION METHOD", 2, 1, Title
        RepeatCH "-", 80, Lin
        FOR I = 1 TO NUMGROUPS%
            PlaceText STR$(LOCAT(I).CODE) + " " + LOCAT(I).NAME + "  [" + LOCAT(I).METHOD + "]", 25, I + 2,
Text
        NEXT I
        RepeatCH "-", 80, Lin
        '
        PlaceText "SCEM = use SCEM model", 2, 20, Inst
        PlaceText "MICR = use real micronenvironmental data", 2, 21, Inst
        RepeatCH "_", 80, Lin
        LOCATE 23, 1
        COLOR Quit
        INPUT "Enter Number of Parameter to Change or 0 to quit: ", I%
        '
        CLS
        IF I% <> 0 AND I% <= NUMGROUPS% THEN
            IF LOCAT(I%).METHOD = "SCEM" THEN LOCAT(I%).METHOD = "MICR" ELSE LOCAT(I%).METHOD = "SCEM"
            CALCOPT$ = LOCAT(I%).METHOD  'overall method is set to last indiv. one
        END IF
        IF I% = 0 THEN OPT% = 1
        CLS
    WEND
END SUB

SUB Calender (date1, M, D, Y) STATIC
'**Calculates Julian date given the month, day and year.
'**12/31/93 ==> 93365& (<yr.><days after 1/1>)
    IF M = 1 THEN X = D
    IF M = 2 THEN X = 31 + D
    IF Y = 87 AND M = 3 THEN X = 59 + D
    IF Y = 88 AND M = 3 THEN X = 60 + D
    IF Y = 87 AND M = 4 THEN X = 90 + D
    IF Y = 88 AND M = 4 THEN X = 91 + D
    IF Y = 87 AND M = 5 THEN X = 120 + D
    IF Y = 88 AND M = 5 THEN X = 121 + D
    IF Y = 87 AND M = 6 THEN X = 151 + D
    IF Y = 88 AND M = 6 THEN X = 152 + D
    IF Y = 87 AND M = 7 THEN X = 182 + D
    IF Y = 88 AND M = 7 THEN X = 183 + D
    IF Y = 87 AND M = 8 THEN X = 212 + D
    IF Y = 88 AND M = 8 THEN X = 213 + D
    IF Y = 87 AND M = 9 THEN X = 243 + D
    IF Y = 88 AND M = 9 THEN X = 244 + D
    IF Y = 87 AND M = 10 THEN X = 273 + D
    IF Y = 88 AND M = 10 THEN X = 274 + D
    IF Y = 87 AND M = 11 THEN X = 304 + D
    IF Y = 88 AND M = 11 THEN X = 305 + D
    IF Y = 87 AND M = 12 THEN X = 334 + D
    IF Y = 88 AND M = 12 THEN X = 335 + D
        date1 = Y * 1000 + X
END SUB

'-------------------
SUB ClearProfile (N%, PROFILE%())
'routine for clearing a 1-D vector PROFILE% of length N%
    FOR I = 1 TO N%
        PROFILE%(I) = 0
    NEXT I
END SUB

SUB ClearVector (N%, VECTOR())
'routine for clearing a 1-D vector VECTOR of length N%
    FOR I = 1 TO N%
        VECTOR(I) = 0
    NEXT I
```

```
END SUB

SUB Diary (WH%, LOCATION%(), SMOKERS%(), ACTIVITY%())
'
'**subprogram to place codes into beginning minute of diary event
'  into 1440 minute profiles: Creates constant length diaries
'  from an arbitrary number of diary events (tbeg = beginning diary time)
'
'   calculates adjusted time and assigns values to
'        LOCATION, ACTIVITY, SMOKERS vectors
'
    t1 = INT(tbeg / 100)
    t2 = (tbeg / 100 - t1) * 100
    '
    '...Convert Time to Minutes
    mins = t1 * 60 + t2
    MINSADJ = mins + 1
    '
    LOCATION%(MINSADJ) = WH%
    SMOKERS%(MINSADJ) = DSMOKE
    ACTIVITY%(MINSADJ) = ACT
    '
END SUB

SUB DoTitle
'
'** sub program to display title screen
'
   COLOR 14, Back
   CLS
   PRINT : PRINT : PRINT : PRINT
   PRINT "              ***********************************************"
   PRINT "              *              Welcome to the                 *"
   PRINT "              *                                             *"
   PRINT "              *         Total Human Exposure Model          *"
   PRINT "              *                 (THEM)                      *"
   PRINT "              *                                             *"
   PRINT "              *                Version 1.0                  *"
   PRINT "              *                                             *"
   PRINT "              *    This version calculates RSP exposure     *"
   PRINT "              *   based on actual Human Activity Patterns   *"
   PRINT "              *                                             *"
   PRINT "              *       Developed at Stanford University      *"
   PRINT "              *                August 1993                  *"
   PRINT "              ***********************************************"
   PRINT
   PRINT "              Press any key to continue..."
   SLEEP: CLS
END SUB

SUB EnterDist (VECTOR())
'
'** subprogram reads data into a univariate
'**   cumulative probablility 2D array VECTOR
'** Data is read until a "99" is encountered
'** VECTOR must be at least a  2xN% array: VECTOR(2, N%)
'
    N% = 1
    TEST1 = 0  'variables to test for end of data by reading a 99
    TEST2 = 0
    LINE INPUT #2, h$    'there is one dummy line for distrib. label
    DO WHILE TEST1 <> 99 AND TEST2 <> 99
        INPUT #2, TEST1, TEST2
        VECTOR(1, N%) = TEST1
        VECTOR(2, N%) = TEST2
        N% = N% + 1
    LOOP
    N% = N% - 1
'
END SUB

SUB EnterLNorm (VECTOR())
'
'** subprogram reads data for geo. mean and geo. std. dev.
'   into array VECTOR(2)
'
        LINE INPUT #2, h$
        INPUT #2, TEST1, TEST2
        VECTOR(1) = TEST1    'geo. mean
        VECTOR(2) = TEST2    'geo. standard deviation
'
```

```
END SUB

SUB ExcludeMenu
'
'** this subprogram displays the menu for excluding exposure from
'    certain microenvironments
'
    OPT% = 0
    CLS
    WHILE OPT% = 0
        PlaceText "EXCLUDE MICROENVIRONMENTS", 2, 1, Title
        RepeatCH "-", 80, Lin
        FOR I = 1 TO NUMGROUPS%
            PlaceText STR$(LOCAT(I).CODE) + " " + LOCAT(I).NAME + "  [" + LOCAT(I).EXCLUDE + "]", 25, I + 2,
Text
        NEXT I
        RepeatCH "-", 80, Lin
        '
        PlaceText "X = exclude location", 2, 20, Inst
        PlaceText "O = include location", 2, 21, Inst
        RepeatCH "_", 80, Lin
        LOCATE 23, 1
        COLOR Quit
        INPUT "Enter Number of Parameter to Change or 0 to quit: ", I%
        '
        CLS
        IF I% <> 0 AND I% <= NUMGROUPS% THEN
            IF LOCAT(I%).EXCLUDE = "X" THEN LOCAT(I%).EXCLUDE = "O" ELSE LOCAT(I%).EXCLUDE = "X"
        END IF
        IF I% = 0 THEN OPT% = 1
        CLS
    WEND
END SUB

'--------------------
SUB Fill (PROFILE%(), N%)
'...Subroutine to fill activity codes into the vector PROFILE()
'.....The vector PROFILE(1440) stores 1-minute activity codes for the Day
'.....In the filling process, if a code other than zero is encounted,
'.......then repeatedly enter the same code until the next nonzero code appears
'
    temp% = 0
    FOR I = 1 TO N%
        IF PROFILE%(I) <> temp% AND PROFILE%(I) <> 0 THEN temp% = PROFILE%(I)
        PROFILE%(I) = temp%
    NEXT I
'
END SUB

SUB FindPersonID (PID&, FILENAME$)
'
'** subroutine to forward in the activity file until it finds person with
'**        identification number ID#
'** assumes activity input file #1 (FILENAME$) is already open
'
        CLOSE #1                        'must start beginning so close, then,
        CALL OpenFile(FILENAME$, 1, 1)   'open file for input as #1
        '
        CLS
        PRINT "Searching...."
        COUNT& = 0  'count number of lines from top
        ID& = -1
        WHILE ID& <> PID& AND NOT EOF(1)
            LOCATE 3, 1: PRINT "READING RECORD #: "; COUNT&
            COUNT& = COUNT& + 1
            INPUT #1, ID&
            'PRINT ID&
        WEND
        '
        'Position at top of file
        '
        CLOSE #1
        CALL OpenFile(FILENAME$, 1, 1)
        '
        PRINT
        '
        IF EOF(1) THEN
           PRINT "End of file reached. Person ID "; PID&; " not found."
           PID& = 0
           PRINT "Press any key...": SLEEP
        ELSE
```

```
            PRINT "Person ID "; PID&; " found.": PRINT
            '
            'after closing file and opening to get back to top
            'then go to COUNT% line #
            '
            '
            FOR I = 1 TO COUNT& - 1  'go to just before found PID
                INPUT #1, DUM
                'PRINT DUM&
            NEXT I
            '
            PRINT "File Pointer Positioned.": PRINT
            PRINT "Press any key...": SLEEP
        END IF
'
END SUB

SUB GetLoc
'
'** sub program to read THEMLOC.DAT file containing regrouped locations
'     and constant RSP concentrations due to ETS
'     "NUMGROUPS%" IS A GLOBAL VARIABLE
'
        '
        PRINT "Reading Location Codes File..."
        '
        OpenFile PATH$ + "THEMLOC.DAT", 2, 1   'open #2 for input
        '
        'skip 15 comment lines
        '
        FOR I = 1 TO 15
            LINE INPUT #2, SP$
        NEXT I
        '
        'Read Number of Groups; dimension location array
        '
        INPUT #2, NUMGROUPS%
        REDIM LOCAT(1 TO NUMGROUPS%) AS LOCCODES
        '
        'set LOCAT.EXCLUDE option to include all locations
        FOR I = 1 TO NUMGROUPS%
            LOCAT(I).EXCLUDE = "O"
        NEXT I
        '
        'set calculation method for each location
        'FOR I = 1 TO NUMGROUPS%
        '    IF CALCOPT$ = "SCEM" THEN LOCAT(I).METHOD = "SCEM" ELSE LOCAT(I).METHOD = "MICRO"
        'NEXT I
        '
        'read new code #, location name, CAP codes to regroup, RSP conc.
        '  all one one line
        '
        FOR I = 1 TO NUMGROUPS%
            LINE INPUT #2, L$
            LOCAT(I).CODE = GetFromStringN(L$, 1)
            LOCAT(I).NAME = GetFromStringS(L$, 2)
            LOCAT(I).NGROUP = GetFromStringN(L$, 3)   'number of regrouped codes
            FOR J = 1 TO LOCAT(I).NGROUP
                LOCAT(I).REGROUP(J) = GetFromStringN(L$, J + 3)
            NEXT J
            LOCAT(I).METHOD = GetFromStringS(L$, LOCAT(I).NGROUP + 4)
        NEXT I
        '
        CLOSE #2
        '
END SUB

SUB GoToPerson (N%)
'
'** subprogram to skip through CAP activity file 'N&' people
'
        CLOSE #1                        'close then open to get to beginning
        CALL OpenFile(INFILE$, 1, 1)
        '
        CLS
        COUNT% = 0
        INPUT #1, PID&
        FOR I = 1 TO N%
            LASTPID& = PID&
            DO UNTIL PID& <> LASTPID&
               INPUT #1, PID&
```

```
            PRINT LASTPID&, PID&: SLEEP
            COUNT% = COUNT% + 1    'number of lines from top
         LOOP
         LOCATE 1, 1: PRINT "Person Number "; I; " Read."
      NEXT I
      '
      'Position at top of file
      '
      PRINT
      '
      IF EOF(1) THEN
         PRINT "End of file reached before person number "; N%
         PID& = 0
         PRINT "Press any key...": SLEEP
      ELSE
         PRINT "Person ID "; PID&; " found.": PRINT
         '
         'after closing file and opening to get back to top
         'then go to COUNT% line #
         '
         CLOSE #1
         CALL OpenFile(INFILE$, 1, 1)
         '
         FOR I = 1 TO COUNT& - 1  'go to just before found PID
             INPUT #1, DUM
             'PRINT DUM&
         NEXT I
         '
         PRINT "File Pointer Positioned."; COUNT% - 1; " lines from top.": PRINT
         PRINT "Press any key...": SLEEP
      END IF
      '
END SUB

SUB GraphProfile (LOCATION%(), SMOKERS%(), RSP())
'
'** subprogram to draw a graphical represention (in character format) on the
'   screen of a combined location, smoking, exposure profile.
'
      'locations and smoker presence are shown by codes
      'exposure is shown with a number whenever a smoker is present
      '
      'HORIZ: 1440 minutes/80 characters = 18 minutes per character
      'VERT: 10 max/24-2 characters  ~ 0.5 units per characters
      '
      COLOR White, Blue
      CLS
      PRINT "Person Number: ", PEOPLE%, "   PID: ", LASTPID&
      PRINT "X=Exposure   L=Location   S=Smoker Present"
      '
      O$ = "#"
      FOR I = 1 TO 1440
          IF I / 18 = CINT(I / 18) THEN
             X% = CINT(I / 18)
             LOCY% = LOCATION%(I)
             IF SMOKERS%(I) = 1 THEN SMOKY% = 10 ELSE SMOKY% = 0
             'LOCY% = 5: SMOKY% = 7
             LOCATE 23, X%: PRINT USING O$; RSP(I)
             'LOCATE LOCY%, X%: PRINT LOCATION%(I)
             'LOCATE SMOKY%, X%: PRINT SMOKERS%(I)
          END IF
      NEXT I
      '
END SUB

SUB Initialize
    '
    PATH$ = "d:\them\basic\"    'Path for finding data files: locations, distributions
    '
    'Histogram BarWidths
    '
    BarWidthAve = 10    'Bar width for Average Indoor
    BarWidthAmb = 5     'Bar width for ambient exp.
    BarWidthMax = 25    'Bar width for Maximum exp.
    '
    HOPT% = 0           'Specify only Barwidth for histogram
    '
    '***** INITIALIZE COUNTERS AND ARRAYS *****
    'Initialize Person Record No. Counter (Counts records for each person)
      RECPERSON& = 0
    'Initialize Total Record No. Counter  (Counts all records read)
```

```
      RECTOTAL& = 0
    'Initialize Person No. Counter  (Counts people)
      PEOPLE% = 0
    'Initialize Person ID Memory  (Stores PID)
      LASTPID& = 0
      PID& = 0
    '
    'Arrays are initialized for profiles and exp in ProcessPerson sub
    '
    'Expand printer width to 120 characters
    WIDTH LPRINT 120
    '
    'Reseed Random Number Generator
    '
    'RANDOMIZE TIMER
    RANDOMIZE 1       'KEEP SAME SEED FOR NOW
    '
END SUB

SUB InitializeHead
'
'** subprogram to initialize headers for exposure data files
'              POPFILE$ AND TALLYFILE$
'
    'write title to exposure data file
    IF POPFILE$ = "" THEN
       WHILE POPFILE$ = ""
           CLS
           PRINT "Exposure data file cannot be NULL."
           INPUT "Enter filename: "; POPFILE$
       WEND
    END IF
    '
    OpenFile POPFILE$, 2, 3   'open file #2 for append
    '
    PRINT #2, "        SUMMARY OF 24-HOUR AVERAGE HUMAN RSP EXPOSURES (ug/m3)"
    PRINT #2,
    PRINT #2, "    #   PID  A S X  Ave. Micro. Max.Min.Micro. Ave. Ambient  Tot.Hour.Max."
    PRINT #2, "================================================================================"
    CLOSE #2
    '
    'write header to exposure-time tally file
    IF TALLYFILE$ <> "" THEN
        OpenFile TALLYFILE$, 2, 3   'open file #2 for append
    '
        PRINT #2, "  TALLY OF MINUTES OF EXPOSURE FOR EACH PERSON "
        PRINT #2, "    IN EACH OF "; NUMGROUPS%; " LOCATIONS"
        PRINT #2,
        PRINT #2, "     #     PID";
        O$ = "    \  \"
        FOR I = 1 TO NUMGROUPS%
            PRINT #2, USING O$; LOCAT(I).NAME;
        NEXT I
        PRINT #2, USING O$; " TOT"
        PRINT #2, "================================================================================"
        CLOSE #2
    END IF
'
END SUB

SUB MainMenu (CHOICE$)
'
'** sub program to process main menu
'
        COLOR , Red: CLS    'Red background
        PlaceText "M A I N     M E N U", 2, 2, 26
        RepeatCH "=", 80, 13
        PlaceText "*EXPOSE A PERSON OR POPULATION*", 2, 4, SubT
        PlaceText "D-Show Details of an Exposure Calculation for One Person", 13, 5, 11
        PlaceText "N-Calculate Exposures for N People", 13, 6, 11
        PlaceText "A-Calculate Exposures for All People", 13, 7, 11
        PlaceText "V-View Current Poplation Exposure File: " + POPFILE$, 13, 8, 11
        PlaceText "E-Erase Current Population Exposure File  (" + STR$(PEOPLE%) + " people)", 13, 9, 11
        RepeatCH ".", 80, 10
        PlaceText "*VIEW/CONTROL INPUT DATA*", 2, 11, SubT
        PlaceText "R-Restart with Person #1 in Activity File: " + INFILE$, 13, 12, 11
        PlaceText "G-Go to a Person Number", 13, 13, 11
        PlaceText "F-Find a Specific Person ID (Next PID = " + STR$(PID&) + ")", 13, 14, 11
        PlaceText "L-Look at Contents of Activity File", 13, 15, 11
        PlaceText "S-Show Location Codes and Distribution Parameters", 13, 16, 11
        RepeatCH ".", 80, 10
```

```
        PlaceText "*CHANGE OPTIONS*", 2, 18, SubT
        PlaceText "O-Change Calculation Options and Input/Output Filenames", 13, 19, 11
        PlaceText "C-Control Output of Calculation Progress to Screen & Line Printer", 13, 20, 11
        RepeatCH "-", 80, 13
        PlaceText "Q-Quit", 2, 22, 15
        RepeatCH "=", 80, 13
        PlaceText "Press Your Choice Letter...", 2, 24, 14
        CHOICE$ = GetAKey("")
        '
        'Processing of Menu Selection in main program section
'
END SUB

FUNCTION MicroExp (LOCATION%, ACTIVITY%, SMOKER%)
'
'** sub program to assign exposures based on distributions of
'   microenvironmental data for each location
'** and activity/smoker codes;  here, smoker = 1 means smoker present
'
         'Assign Exposures
         '
         FOR J = 1 TO NUMGROUPS%
             IF LOCATION% = LOCAT(J).CODE THEN
                 CURRENTRSP = DistSample(LOCAT(J).ETSDIST())
                 LOCAT(CURRENTLOC%).SAMPLE = CURRENTRSP
                 MicroExp = CURRENTRSP
             END IF
         NEXT J
         '
END FUNCTION

SUB OptionsMenu
'
'** subprogram to display and process Options menu
'
    OPT% = 0
    WHILE OPT% = 0
        PlaceText "OPTIONS, FILES", 2, 1, Title
        RepeatCH "-", 80, Lin
        PlaceText "A-Input file for Activity Patterns         [" + INFILE$ + "]", 10, 3, Text
        PlaceText "B-Input file for Ambient Data              [" + AMBFILE$ + "]", 10, 4, Text
        PlaceText "P-Output file for Population Exposure Data [" + POPFILE$ + "]", 10, 5, Text
        '
        PlaceText "T-Output file for Exposure-Time Tally      [" + TALLYFILE$ + "]", 10, 7, Text
        PlaceText "E-Output file for Exposure Profiles        [" + EXPFILE$ + "]", 10, 8, Text
        PlaceText "V-Output file for Activity Codes           [" + ACTFILE$ + "]", 10, 9, Text
        PlaceText "L-Output file for Location Codes           [" + LOCFILE$ + "]", 10, 10, Text
        PlaceText "S-Output file for Smoking Codes            [" + SMOKFILE$ + "]", 10, 11, Text
        PlaceText "H-Output file for Hourly Summaries         [" + HOURFILE$ + "]", 10, 12, Text
        PlaceText "R-Output file for 'RSP Episode' Parameters [" + SCEMFILE$ + "]", 10, 13, Text
        PlaceText "(To View a File Press ` and Enter Filename)", 2, 14, Inst
        PlaceText "X-Delete Person Output Files", 10, 15, Text
        '
        PlaceText "0-Exclude Locations", 10, 17, Text
        PlaceText "1-Assign Exposure Method", 10, 18, Text
        '
        PlaceText "2-Read Ambient Data?                     [" + AMBOPT$ + "]", 10, 20, Text
        PlaceText "3-Regroup Locations?                     [" + GROUPOPT$ + "]", 10, 21, Text
        '
        PlaceText "Press <RET> to enter options...", 2, 22, Inst
        RepeatCH "_", 80, Lin
        PlaceText "Press a Letter or Number...", 2, 24, Quit
        OPTIONN$ = GetAKey("")
        '
        CLS
        SELECT CASE OPTIONN$
            CASE "a", "A": INPUT "Enter name for Activity File: ", INFILE$
                   CLOSE #1: CALL OpenFile(INFILE$, 1, 1)
            CASE "b", "B": INPUT "Enter name for Ambient Data File: ", AMBFILE$
            CASE "p", "P": INPUT "Enter name for Exposure Data File: ", POPFILE$
            CASE "E", "e": PRINT "Enter name for file to contain Exposure Vectors"
                   INPUT "Press <RET> for no file: ", EXPFILE$
            CASE "T", "t": PRINT "Enter name for file to contain Exposure Tally"
                   INPUT "Press <RET> for no file: ", TALLYFILE$
            CASE "v", "V": PRINT "Enter name for file to contain Activity Codes"
                   INPUT "Press <RET> for no file: ", ACTFILE$
            CASE "l", "L": PRINT "Enter name for file to contain Location Codes"
                   INPUT "Press <RET> for no file: ", LOCFILE$
            CASE "s", "S": PRINT "Enter name for file to contain Passive Smoking Codes"
                   INPUT "Press <RET> for no file: ", SMOKFILE$
            CASE "h", "H": PRINT "Enter name for file to contain Houly Summaries"
```

```
                INPUT "Press <RET> for no file: ", HOURFILE$
            CASE "r", "R": PRINT "Enter name for file to contain SCEM Parameters"
                INPUT "Press <RET> for no file: ", SCEMFILE$
            CASE "`": CLS : INPUT "Enter filename:"; FIL$
                 LookAtFile FIL$
            CASE "x", "X": CLS
                PRINT "Press <RET> to !DELETE! all person output files"
                PRINT "or Press <ESC> to CANCEL ": ANS$ = GetAKey("")
                IF ANS$ = CHR$(13) THEN    'if RET
                    KILL TALLYFILE$
                    KILL EXPFILE$
                    KILL ACTFILE$
                    KILL LOCFILE$
                    KILL SMOKFILE$
                    KILL HOURFILE$
                    KILL SCEMFILE$
                END IF
            CASE "0": ExcludeMenu
            CASE "1": AssignMenu
            CASE "2": IF AMBOPT$ = "Yes" THEN AMBOPT$ = "No" ELSE AMBOPT$ = "Yes"
            CASE "3": IF GROUPOPT$ = "Yes" THEN GROUPOPT$ = "No" ELSE GROUPOPT$ = "Yes"
            CASE CHR$(13): OPT% = 1    'press <RET> to enter..
            CASE ELSE
        END SELECT
        COLOR , 4: CLS    'red background
    WEND
END SUB

SUB PrintEpisode (HEAD$)
'
'** sub program to save SCEM parameters for each location for each person
'**   gives new set of params for each new smoker location
'
        LPRINT
        LPRINT "*****************************************************************"
        LPRINT "LIST OF SCEM PARAMETERS"
        LPRINT
        LPRINT HEAD$
        LPRINT
        OA$ = "Room Volume (m3):   ######     Source Strength (ug/cig.): #####"
        OB$ = "Smoking Rate (hr-1): ###.#     Air Exchange Rate (ach):  ####.#"
        OC$ = "Smoker Location:       ###     Average Conc. (ug/m3):   #####.#"
        LPRINT USING OA$; SCEM.VOLUME; SCEM.SOURCE
        LPRINT USING OB$; SCEM.SMRATE; SCEM.ACH
        LPRINT USING OC$; SCEM.SMLOC; SCEM.AVECONC
        LPRINT "*****************************************************************"
'
END SUB

SUB PrintHourlySum (HEAD$, N%, RSP(), AMBIENT())
'
'** sub program for printing hourly summary to line printer
'
        'SetPrintStyle "4"   'cond print
        LPRINT
        LPRINT "************************************************"
        LPRINT "SUMMARY OF AVERAGE HOURLY EXPOSURE (ug/m3)"
        LPRINT
        LPRINT HEAD$
        LPRINT
        LPRINT "  TIME         INDOOR         AMBIENT"
        LPRINT "---------------------------------------"
        O$ = " ##:00        ####.#         ####.#"
        FOR I = 1 TO 24
            INDOOR = Average((I - 1) * 60 + 1, I * 60, RSP(), 0, OMITOUT)
            IF AMBIENT(I) < 0 THEN AMBIENT(I) = 0
            LPRINT USING O$; I; INDOOR; AMBIENT(I)
        NEXT I
        O2$ = "OVERALL       ####.#         ####.#"
        LPRINT "-------------------------------------"
        LPRINT USING O2$; Average(1, 1440, RSP(), 0, OMITOUT); Average(1, 24, AMBIENT(), 0, OMITOUT)
        LPRINT "************************************************"
        PrinterControl "FF"    'new printer page
'
END SUB

SUB PrintOutOptions
'
'** sub program to handle write/printout/saving of calculation progress
'
    RUNOPT% = 0
```

```
    CLS
    WHILE RUNOPT% = 0
        PlaceText "SCREEN AND PRINTER OPTIONS", 2, 4, 10
        RepeatCH "-", 80, 13
        PlaceText "1-Personal Data to Screen                  [" + RT1$ + "]", 2, 6, 11
        PlaceText "2-Location & Activity Profiles to Screen   [" + RT2$ + "]", 2, 7, 11
        PlaceText "3-Indoor Exposures to Screen               [" + RT3$ + "]", 2, 8, 11
        PlaceText "4-Hourly Summary of Each Person to Screen  [" + RT5$ + "]", 2, 9, 11
        RepeatCH "-", 80, 13
        PlaceText "5-Pause Calculation Between People         [" + RT4$ + "]", 2, 11, 11
        RepeatCH "-", 80, 13
        PlaceText "6-Location & Activity Profiles to Printer  [" + RT6$ + "]", 2, 13, 11
        PlaceText "7-Indoor Exposures to Printer              [" + RT7$ + "]", 2, 14, 11
        PlaceText "8-Hourly Summary of Each Person to Printer [" + RT8$ + "]", 2, 15, 11
        PlaceText "9-SCEM Parameters of Each Person to Printer [" + RT10$ + "]", 2, 16, 11
        RepeatCH "-", 80, 13
        PlaceText "0-Pause Between New Smoking Episodes       [" + RT9$ + "]", 2, 18, 11
        RepeatCH "-", 80, 13
        PlaceText "Press <RET> to Enter Options Choices", 2, 20, 15
        RepeatCH "_", 80, 14
        PlaceText "Press Number of Option to Toggle...", 2, 22, 14
        ROPT$ = GetAKey("")
        SELECT CASE ROPT$
            CASE "1": IF RT1$ = "Yes" THEN RT1$ = "No " ELSE RT1$ = "Yes"
            CASE "2": IF RT2$ = "Yes" THEN RT2$ = "No " ELSE RT2$ = "Yes"
            CASE "3": IF RT3$ = "Yes" THEN RT3$ = "No " ELSE RT3$ = "Yes"
            CASE "4": IF RT5$ = "Yes" THEN RT5$ = "No " ELSE RT5$ = "Yes"
            CASE "5": IF RT4$ = "Yes" THEN RT4$ = "No " ELSE RT4$ = "Yes"
            CASE "6": IF RT6$ = "Yes" THEN RT6$ = "No " ELSE RT6$ = "Yes"
            CASE "7": IF RT7$ = "Yes" THEN RT7$ = "No " ELSE RT7$ = "Yes"
            CASE "8": IF RT8$ = "Yes" THEN RT8$ = "No " ELSE RT8$ = "Yes"
            CASE "9": IF RT10$ = "Yes" THEN RT10$ = "No " ELSE RT10$ = "Yes"
            CASE "0": IF RT9$ = "Yes" THEN RT9$ = "No " ELSE RT9$ = "Yes"
            CASE CHR$(13): RUNOPT% = 1    'hit RET to enter options
            CASE ELSE
        END SELECT
    WEND
END SUB

SUB PrintProfile (HEADER$, VECTOR%())
'
'** subprogram for printing profiles to the line printer
'
        DIM OUTFIELD AS STRING * 3
        DIM OUT$
        '
        LPRINT "********************************************************************************"
        LPRINT HEADER$
        L$ = "Grid of 24 hours vs. 60 minutes per hour"
        L1$ = " HRS- 1     3     5     7     9    11    13    15    17    19    21    23"
        L2$ = "MINS     2     4     6     8    10    12    14    16    18    20    22    24"
        LPRINT L$
        LPRINT L1$
        LPRINT L2$
        LPRINT "--|-------------------------------------------------------------------------------"
        FOR I = 1 TO 60
            OUT$ = ""
            CALL FillString(I, OUTFIELD, OUT$, 3, 3)
            OUT$ = OUT$ + "="
            FOR J = 1 TO 24
                Value = INT(VECTOR%(I + (J - 1) * 60))
                CALL FillString(Value, OUTFIELD, OUT$, 3, 3)
            NEXT J
            LPRINT OUT$
        NEXT I
        LPRINT "********************************************************************************"
        PrinterControl "FF"   'new printer page
'
END SUB

'---------------------
SUB PrintSegs (Offset%, PROFILE%()) STATIC
    LPRINT "    Offset Time = ", Offset%, "minutes"
    LPRINT : LPRINT "24-Hour Profile Summary by 4 Segments per Hour:": LPRINT
    LPRINT "  Hour        Seg1          Seg2     Seg3     Seg4 "
    FOR h = 1 TO 24
        I = (4 * (h - 1) + 1)
        LPRINT "    "; (h - 1), PROFILE%(I), PROFILE%(I + 1), PROFILE%(I + 2), PROFILE%(I + 3)
    NEXT h
    LPRINT : LPRINT
END SUB
```

```
SUB PrintVector (HEADER$, VECTOR())
'
'** subprogram for printing exposure vectors to line printer
'
        DIM OUTFIELD AS STRING * 3
        DIM OUT$
        '
        LPRINT
        LPRINT "********************************************************************************"
        LPRINT HEADER$
        L$ = "Vector grid of 24 hours vs. 60 minutes per hour"
        L1$ = " HRS- 1     3     5     7     9    11    13    15    17    19    21    23"
        L2$ = "MINS     2     4     6     8    10    12    14    16    18    20    22    24"
        LPRINT L$
        LPRINT L1$
        LPRINT L2$
        LPRINT "--|-------------------------------------------------------------------------"
        FOR I = 1 TO 60
            OUT$ = ""
            CALL FillString(I, OUTFIELD, OUT$, 3, 3)
            OUT$ = OUT$ + "="
            FOR J = 1 TO 24
                Value = INT(VECTOR(I + (J - 1) * 60))
                CALL FillString(Value, OUTFIELD, OUT$, 3, 3)
            NEXT J
            LPRINT OUT$
        NEXT I
        LPRINT "********************************************************************************"
        PrinterControl "FF"   'new printer page
'
END SUB

SUB ProcessPerson
'
'** sub program to handle control of reading activity data, calculating
'   RSP exposure and saving person exposure data.
'
        '
        'Dimension arrays for profiles and exposure
        '*****************************************************************
        DIM LOCATION%(1440) '1440 min location profile for each person
        DIM ACTIVITY%(1440) '1440 min activity profile for each person
        DIM SMOKERS%(1440)  '1440 min smoker-present profile for each person
        DIM AMBIENT(24)     'hourly ambient data
        DIM RSP(1440)       'RSP From indoor sources
        '*****************************************************************
        '
        '|------------------------Read Activities-------------------------|
        '|----------------------and Create Profiles-----------------------|
        '
        ReadNextPerson LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP(), AMBIENT()
        '
        '
        'Save profiles to file
        SaveWriteActivity LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP(), AMBIENT()
        '
        '|---------------------------------------------------------------|
        '
        '|----------------- Calculate Exposure --------------------------|
         '
        '1. read ambient data
        '2. calculates exposures from ambient and const. indoor RSP values
        '
        'clear ambient and microenvironmental exposure profiles
        CALL ClearVector(24, AMBIENT())
        CALL ClearVector(1440, RSP())
        '
        'get ambient data
        IF AMBOPT$ = "Yes" THEN
            CALL UpdateScreen("Reading Ambient Data")
            'CALL AmbientArray(AMBIENT(), date2, DATE, AMBDATA())
            CALL AmbientFile(AMBIENT(), date2, DATE, AMBFILE$)
        END IF
        '
        CALL UpdateScreen("Calculating Microenvironmental Exposure")
        '
        'Fill-In Exposure Profile: calls subprograms MicrExp and SCEMExp
        RSPFill LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP()
        '
        'Save exposures/hourly summaries/parameters to file
```

```
        SaveWriteExposure LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP(), AMBIENT()
        '
        '|-------------------------------------------------------------|
        '
        '|----------- Store 24-hour Exposures, Tally  -------------------|
        '
        StorePerson AMBIENT(), RSP()
        '
        '|-------------------------------------------------------------|
        '
END SUB

SUB ReadAmbient
'
'** sub program to read ambient data from file into AMBDATA$(1000) array
'
    PRINT "Reading Ambient Data..."
    CALL OpenFile(AMBFILE$, 2, 1)   'open as #2 for input
         I = 1
         DO UNTIL EOF(2)
            LINE INPUT #2, AMBDATA(I)
            I = I + 1
         LOOP
    CLOSE #2
'
END SUB

SUB ReadDistParams
'
    '** sub program to read in all parameters for
    '**    distributions
    '** uses sub programs EnterDist and EnterLNDist **
    '
    PRINT "Reading distribution parameters..."
    '
    SP% = 14  'Number of comment lines at top of THEMDIST.DAT file
    '
    OpenFile PATH$ + "THEMDIST.DAT", 2, 1  'open #2 for input
    '
    FOR I = 1 TO SP%
       LINE INPUT #2, SP$
    NEXT I
    '
    '1** Read in parameters for the 100s of sq. ft. of house
    '
    EnterDist FOOTAGE()
    '
    '2** Read in parameters for the air exchange rate for house, ach
    '
    EnterDist EXCHANGE()
    '
    '3** Read in parameters for number of rooms in a house
    '
    EnterDist NUMROOMS()
    '
    '*********************************************************************
    '---------------------------------------------------------------------
    '** The following are the actual data parameters contained in
    '    THEMDIST.DAT with some comments:
    '
    '** FORM: {RANGE LIMIT, CUM. DIST. VALUE}
    '** The user may change the values and number of parameters
    '** A "99,99" is used to signal termination of data
    '
    '
    '** DATA FOR SQ. FOOTAGE OF A HOUSE (square feet)
    '---> Taken from: "Catalogue of Saturations"
    '                  Residential Appliance Saturation Survey
    '                  PG&E Market Planning and Research Dept.
    '                  Market Research and Info. Section, June 1987
    ' 1.000 line estimated
    ' 0.0000001 line estimated
    '
        'DATA 200, 0.0000001
        'DATA 400, 0.014
        'DATA 599, 0.040
        'DATA 999, 0.14
        'DATA 1499, 0.488
        'DATA 1999, 0.782
        'DATA 2699, 0.937
        'DATA 3499, 0.980
```

```
        'DATA 5000, 1.000
        'DATA 99, 99
    '
    '** DATA FOR AIR EXCHANGE RATE OF A HOUSE-TOTAL (ACH)
    '--> Taken from: Table 1; Region 3: The Southwest,
    '                Pandian, Ott, Behar,
    '               "Residential Air Exchange Rates for Use in Indoor Air
    '                and Exposure Modeling Studies", June 1993.
    '1.000 line estimated
    '
        'DATA 0.31, 0.05
        'DATA 0.76, 0.25
        'DATA 2.12, 0.40
        'DATA 4.15, 0.75
        'DATA 10.59, 0.95
        'DATA 15.00, 1.000
        'DATA 99, 99
    '
    '** Data for Number of Rooms in a House
    '---> Taken from: "Catalogue of Saturations"
    '                  Residential Appliance Saturation Survey
    '                  PG&E Market Planning and Research Dept.
    '                  Market Research and Info. Section, June 1987
    '1.000 line estimated
    '
        'DATA 1, 0.002
        'DATA 2, 0.007
        'DATA 3, 0.033
        'DATA 4, 0.132
        'DATA 5, 0.396
        'DATA 6, 0.680
        'DATA 7, 0.840
        'DATA 8, 0.933
        'DATA 9, 0.969
        'DATA 10, 0.986
        'DATA 15, 1.000
        'DATA 99, 99
'
'** Read in log normal geo. mean and geo. st. dev.
'   AND  normal mean and st. dev.
'
'   MUST BE CALLED AFTER: EnterDist for REAL Distributions
'   uses EnterLNorm sub program
'   data format:  log<mean>, log<STD>
'               OR
'                 <mean>, <STD> for NORMAL distributions
'
'   THE LOGARITHMS OF THE VALUES ARE NORMALLY DISTRIBUTED
'   WE ENTER LOG(MEAN) AND LOG(STD) TO GET A LOGNORMAL
'   DISTRIBUTION OF THE ACTUAL VALUES WHEN WE SAMPLE IT WITH
'   LNormSample.
'
'   Conversions: 1 ft3 = 0.02833 m3
'                1 m3 = 35.298 ft3
'                1 ft2 = ? m2
'                1 ft  = ? m
'-----------------------------------------------------------------
'
        EnterLNorm NVEHVOL()
        EnterLNorm NVEHEXCHC()
        EnterLNorm NVEHEXCHO()
        EnterLNorm NSOURCE()
        EnterLNorm NSMRATE()
        '
        '**NORMAL Data for Vehicle Volume--cubic feet
        '
        '  Ott, Langan & Switzer offer:  3.7 m3 = 130.6
        '
        'DATA 150, 50
        '----------------------
        '
        '**NORMAL Data for Vehicle Air Exchange Rate--ach
        '
        '  Ott, Langan & Switzer (1992) offer the following:
        '       Windows Open, 20 mph:    121 ach
        '       Windows Closed, 20 mph:  13.1 ach
        '       Windows Closed, 0 mph:   1.41 ach
        '
        'DATA 75, 20
        '---------------
        '
```

```
        '**NORMAL Data for Source Strength--ug/cig
        '
        '  Ott, Langan & Switzer offer: 49,000 ug/cig
        '  Ott & Klepeis offer: 12,100 ug/cig
        '  Other Researchers offer: ~15,800 ug/cig
        '
        'DATA 12100, 500
        '---------------
        '
        '**NORMAL Data for Smoking Rate--cig/hr
        '
        'DATA 2.0, 0.5
        '---------------
        '
        '****Read in microenvironmental RSP conc. distributions for reduced
        '****Microenvironmental Locations
        '
        FOR I = 1 TO NUMGROUPS%
            EnterDist LOCAT(I).ETSDIST()
        NEXT I
        '
        CLOSE #2
        '
END SUB

SUB ReadNextPerson (LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP(), AMBIENT())
'
'** sub program to handle the input of person diaries and other data
'       and to create the LOCATION, ACTIVITY and SMOKER 1440 minute profiles
'
        '
        'Clear the PROFILE vectors for use with next person
        'They must be cleared to make use of FILL sub program effectively
        '
        'clear ACT and LOC profiles
        '
        CALL ClearProfile(1440, LOCATION%())
        CALL ClearProfile(1440, SMOKERS%())
        '
        '---- Input diary and personal data ----
        '*** Read the data for one person ***
        '*** from the CAP input file: INFILE$ ***
        '1. reads first record  2. reads personal info.  3. regroups loc. codes
        '4. reads remainder of diary records
        '
        'update the person ID and person counter
        '
        'set parameters for New Person
        RECPERSON& = 0
        PEOPLE% = PEOPLE% + 1
        LASTPID& = PID&
        '
        'Input first line of diary data
        'DSMOKE contains 1 for no smoker, 5 for smoker, 0 for no data
        '** Only read 1st diary line here if this is the very top of the file **
        '** otherwise the first entry of the diary was read in from the **
        '** last call to "InputPerson" **
        '
        IF PEOPLE% = 1 THEN INPUT #1, PID&, ID, a.y, tbeg, tend, etim, ctim, where, DSMOKE, ACT, dirm, dird,
diry, dirwkday
        LASTPID& = PID&
        '
        '
        'Convert month/day/year date of diary into Julian date:date1
        'Month, day and year from person input data
        M = dirm
        D = dird
        Y = diry
        CALL Calender(DATE, M, D, Y)
        '
        CALL UpdateScreen("Reading Person")
        '
        'Input all demographic information on current person
        '      and print out after reading in
        INPUT #1, PID&, RN01&, RSEL&, YSEL&, TPAC&, PRFX&, CLST&, STUM&, ACDT&, HHA&, HHAT&, HOUS&, PARK&,
PRK2&, WKJB&, WKHR&, VWHR&, NJOB&, WP1&, WP2&, WP3&, WP4&, WP5&, WP6&
        INPUT #1, PID&, SMOK&, SMKY&, SMK2&, SMY2&, CLC4&, CLC6&, PGAR&, PGYS&, PGAS&, GSTV&, NSTV&, MS1&,
MSTM&, MS2&, GSPR&, GSTM&, PLOT&, HTYS&, HTFL&, HEAT&, OPE&, OPN1&, OPN2&, FAN1&, FAN2&, AIRC&, ACTP&,
GLUE&, PNT1&, PNT2&, SOLV&, PEST&
```

```
        INPUT #1, PID&, PST2&, SOAP&, OCLN&, AERO&, SHWR&, BATH&, MOTH&, DEOD&, RMFR&, AGE&, EDUC&, GDGR&,
MRTL&, ZIP&, CNTY&, AREA&, HHT&, BG15&, BG16&, BG17&, RSEX&, INCM&, INCA&, INCB&, INCC&, INCD&, INCE&,
INCF&, ISUM&, HHTT&, YTJB&
        INPUT #1, PID&, YWHR&, YVHR&, YNJB&, YWP1&, YWP2&, YWP3&, YWP4&, YWP5&, YWP6&, YSTU&, YSMK&, YSMY&,
YSM2&, YSY2&, YCC6&, YCC8&, YPGR&, YPGY&, YPGS&, YSTV&, YNST&, YMS1&, YMSM&, YMS2&, YGSP&, YGTM&, YPLT&,
YGLU&, YPT1&, YPT2&, YSLV&, YPST&,  _
YPS2&
        INPUT #1, PID&, YSP&, YCLN&, YARO&, YSHR&, YBTH&, YAGE&, YEDU&, YSEX&, YCDT&, AOUT&, YOUT&, TTIM&,
INUM&, TCNT&, RCNT&, RANS&, ANYO&, CSUM&, ANUM&, ZTST&, ADIFF&, YDIFF&, NPHONE&, YINTV&, dirmm&, dirdd&,
diryy&
        INPUT #1, PID&, ADWKDAY&, CMPMM&, CMPDD&, CMPYY&, ACWKDAY&, OCC&, YDIRMM&, YDIRDD&, YDIRYY&,
YDWKDAY&, YCMPMM&, YCMPDD&, YCMPYY&, YCWKDAY&, YOCC&, SMOKE&, YSMOKE&, SAMPWT, TIMEWT, YSAMPWT, YTIMEWT
        '
        'print out personal info. to screen
        IF RT1$ = "Yes" THEN
            CALL UpdateScreen("Press any key to view personal data..."): SLEEP: CLS
            PRINT PID&, RN01&, RSEL&, YSEL&, TPAC&, PRFX&, CLST&, STUM&, ACDT&, HHA&, HHAT&, HOUS&, PARK&,
PRK2&, WKJB&, WKHR&, VWHR&, NJOB&, WP1&, WP2&, WP3&, WP4&, WP5&, WP6&: SLEEP: CLS
            PRINT PID&, SMOK&, SMKY&, SMK2&, SMY2&, CLC4&, CLC6&, PGAR&, PGYS&, PGAS&, GSTV&, NSTV&, MS1&,
MSTM&, MS2&, GSPR&, GSTM&, PLOT&, HTYS&, HTFL&, HEAT&, OPE&, OPN1&, OPN2&, FAN1&, FAN2&, AIRC&, ACTP&,
GLUE&, PNT1&, PNT2&, SOLV&, PEST&: _
                            SLEEP: CLS
            PRINT PID&, PST2&, SOAP&, OCLN&, AERO&, SHWR&, BATH&, MOTH&, DEOD&, RMFR&, AGE&, EDUC&, GDGR&,
MRTL&, ZIP&, CNTY&, AREA&, HHT&, BG15&, BG16&, BG17&, RSEX&, INCM&, INCA&, INCB&, INCC&, INCD&, INCE&,
INCF&, ISUM&, HHTT&, YTJB&: SLEEP: CLS
            PRINT PID&, YWHR&, YVHR&, YNJB&, YWP1&, YWP2&, YWP3&, YWP4&, YWP5&, YWP6&, YSTU&, YSMK&, YSMY&,
YSM2&, YSY2&, YCC6&, YCC8&, YPGR&, YPGY&, YPGS&, YSTV&, YNST&, YMS1&, YMSM&, YMS2&, YGSP&, YGTM&, YPLT&,
YGLU&, YPT1&, YPT2&, YSLV&, YPST&,  _
YPS2&: SLEEP: CLS
            PRINT PID&, YSP&, YCLN&, YARO&, YSHR&, YBTH&, YAGE&, YEDU&, YSEX&, YCDT&, AOUT&, YOUT&, TTIM&,
INUM&, TCNT&, RCNT&, RANS&, ANYO&, CSUM&, ANUM&, ZTST&, ADIFF&, YDIFF&, NPHONE&, YINTV&, dirmm&, dirdd&,
diryy&: SLEEP: CLS
            PRINT PID&, ADWKDAY&, CMPMM&, CMPDD&, CMPYY&, ACWKDAY&, OCC&, YDIRMM&, YDIRDD&, YDIRYY&,
YDWKDAY&, YCMPMM&, YCMPDD&, YCMPYY&, YCWKDAY&, YOCC&, SMOKE&, YSMOKE&, SAMPWT, TIMEWT, YSAMPWT, YTIMEWT:
SLEEP: CLS
        END IF
        '
        'Read remainder of diary information
        'Test to see if a new person is present (different PID&)
        'Exit loop if end of file detected or PID <> Last PID
        '
        '******* Enter Loop ********
        WHILE NOT (EOF(1)) AND PID& = LASTPID&
            '
            'regroup locations from "where" into "wh%"
            WH% = where
            IF GROUPOPT$ = "Yes" THEN CALL RegroupLoc(WH%)
            '
            'Place LOC, ACT, SMOK codes into appropriate first minute
            '        of current diary event; tbeg= beginning time
            CALL Diary(WH%, LOCATION%(), SMOKERS%(), ACTIVITY%())
            '
            'Increment Record No. Counters
            RECPERSON& = RECPERSON& + 1
            RECTOTAL& = RECTOTAL& + 1
            '
            'input a new line from diary
            INPUT #1, PID&, ID, a.y, tbeg, tend, etim, ctim, where, DSMOKE, ACT, dirm, dird, diry, dirwkday
            '
        WEND
        '****************************
        '
        IF EOF(1) THEN
           PRINT "End of File Reached...": SLEEP
           ALLSTOP% = 1
        END IF
        '
        'Fill the 1-minute activity profiles with
        '      contiguous values in time
        '
        CALL UpdateScreen("Creating 1440-min. Profiles")
        '
        CALL Fill(LOCATION%(), 1440)
        CALL Fill(ACTIVITY%(), 1440)
        CALL Fill(SMOKERS%(), 1440)
        '
END SUB

SUB RegroupLoc (WH%)
'
'**  sub program to take a location code WH% and regroup it into
```

```
'**   seven more general locations: e.g. 1 home; 2 office factory
'**   ;3 other indoors; 4 bar rest; 5 outdoors ; 6 vehicle ; 0 other
'
    FOR I = 1 TO NUMGROUPS%
        FOR J = 1 TO LOCAT(I).NGROUP
            IF WH% = LOCAT(I).REGROUP(J) THEN WH% = LOCAT(I).CODE
        NEXT J
    NEXT I
'
END SUB

SUB RestartCalc
    '
    '*** Subprogram to end of one run through of data **
    '1. prints out summary of people analyzed
    '2. reinitilizes file INFILE$ for activity input'
    '3. reinitializes parameters
    '
    PRINT "Reinitializing file pointers for "; INFILE$; ". . ."
    PRINT : PRINT "Number of Persons Analyzed = ", PEOPLE%
    PRINT "Number of Records Analyzed =    ", RECTOTAL&
    '
    PRINT
    ANS$ = GetAKey("Press <ESC> to cancel and any other key to initialize...")
    IF ANS$ <> CHR$(27) THEN
    '
        CLOSE #1
        OPEN INFILE$ FOR INPUT AS #1
   '
        '#2 is the ambient data file, opened and closed in AMBEXP sub program
        CALL Initialize
    END IF
END SUB

SUB RetrieveOptions
'
'**sub program to retrieve options from THEM.OPT file
'
ON LOCAL ERROR GOTO ReadError
'
        PRINT "Reading options file..."
        '
        CALL OpenFile("THEM.OPT", 8, 1)    'open file for input
        INPUT #8, INFILE$                  'write options to file
        INPUT #8, AMBFILE$
        INPUT #8, POPFILE$
        INPUT #8, TALLYFILE$
        INPUT #8, EXPFILE$
        INPUT #8, ACTFILE$
        INPUT #8, LOCFILE$
        INPUT #8, SMOKFILE$
        INPUT #8, HOURFILE$
        INPUT #8, SCEMFILE$
        INPUT #8, AMBOPT$
        INPUT #8, GROUPOPT$
        INPUT #8, RT1$
        INPUT #8, RT2$
        INPUT #8, RT3$
        INPUT #8, RT4$
        INPUT #8, RT5$
        INPUT #8, RT6$
        INPUT #8, RT7$
        INPUT #8, RT8$
        INPUT #8, RT9$
        INPUT #8, RT10$
        CLOSE #8
Quit:
EXIT SUB
'
ReadError:
     CLS : BEEP
     PRINT "Error Reading Options File: THEM.OPT": PRINT
     INFILE$ = ""
     PRINT "Press any key to continue...": SLEEP: CLS
RESUME Quit:
'
END SUB

SUB RSPFill (LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP())
'
'** subprogram to fill in the exposure profile with RSP average concentrations
```

```
'
'**  assigns ave. exp. to all minutes during the time in one location
'    RSP() contains the exposure profile
        '
        'Look at segments of exposure over all 1440 minutes of the day
        '--Breaking up into Locations

        'clear exposure array
        CALL ClearVector(1440, RSP())
        '
        'clear tally of "exposure minutes" in each location for last person
        FOR I = 1 TO NUMGROUPS%
            LOCAT(I).TALLY = 0
        NEXT I
        '
'************************************************************************
        'MAIN LOOP TO CREATE 1440-minute EXPOSURE PROFILE
'************************************************************************
        FOR I = 1 TO 1440
          'current location, activity and smoker presence
          CURRENTLOC% = LOCATION%(I)
          CURRENTACT% = ACTIVITY%(I)
          CURRENTSMOK% = SMOKERS%(I)
          '
          ' if a code is outside regrouped range make in the first group: Home
          IF CURRENTLOC% > NUMGROUPS% THEN CURRENTLOC% = 1
          '
          'IF LOCAT(CURRENTLOC%).EXCLUDE = "X" THEN
          '    LOCATE CURRENTLOC%, 1
          '    PRINT "X HERE"
          'END IF
          '
          IF LOCAT(CURRENTLOC%).EXCLUDE <> "X" THEN
            '
            'LOCATE CURRENTLOC%, 1
            'PRINT "O HERE"
            '
            SELECT CASE SMOKERS%(I)
                CASE 1           'a smoker is present
                    '
                    'add 1-minute to the tally in current location
                    LOCAT(CURRENTLOC%).TALLY = LOCAT(CURRENTLOC%).TALLY + 1
                    '
                    IF LOCATION%(I) = LOCATION%(I - 1) AND INT(RSP(I - 1)) <> 0 AND I <> 1 THEN
                       RSP(I) = RSP(I - 1)
                    ELSEIF LOCATION%(I) <> LOCATION%(I - 1) OR INT(RSP(I - 1)) = 0 OR I = 1 THEN
                       IF LOCAT(CURRENTLOC%).METHOD = "SCEM" THEN RSP(I) = SCEMExp(LOCATION%(I))
                       IF LOCAT(CURRENTLOC%).METHOD = "MICR" THEN RSP(I) = MicroExp(LOCATION%(I),
ACTIVITY%(I), SMOKERS%(I))
                       UpdateScreen ("A New Smoking Episode " + "(" + LOCAT(CURRENTLOC%).NAME + ")")
                       '
                       LASTEXPOS = RSP(I)
                       '
                       'Print or display smoker episode information
                       '
                       IF RT9$ = "Yes" THEN
                          CALL UpdateScreen("Smoker Present: '" + LOCAT(CURRENTLOC%).METHOD + "' Method...")
                          SLEEP
                       END IF
                       HEAD$ = "PERSON # " + STR$(PEOPLE%) + " / PID #" + STR$(LASTPID&) + " / " + INFILE$ +
""
                       IF RT10$ = "Yes" THEN
                           CALL UpdateScreen("Printing Parameters to Line Printer")
                           CALL PrintEpisode(HEAD$)
                       END IF
                       IF LOCAT(CURRENTLOC%).METHOD = "SCEM" AND SCEMFILE$ <> "" THEN
                          CALL UpdateScreen("Saving SCEM Parameters to File")
                          CALL SaveSCEM(HEAD$)
                       END IF
                       '
                    END IF
                    '
                CASE ELSE
                    '
            END SELECT
          END IF
        NEXT I
'************************************************************************
END SUB

SUB SaveHourlySum (RSP(), AMBIENT())
```

```
'
'** subprogram to save hourly average summary to file
'
        CALL OpenFile(HOURFILE$, 2, 3) 'append #2 for each person
        '
        PRINT #2, " "
        PRINT #2, "HOURLY SUMMARY OF EXPOSURE (ug/m3)"
        PRINT #2, "     FOR PERSON # "; PEOPLE%
        PRINT #2, " "
        PRINT #2, "TIME         INDOOR        AMBIENT"
        PRINT #2, "-----------------------------------"
        O$ = " ##:00        ####.#         ####.#"
        FOR I = 1 TO 24
            INDOOR = Average((I - 1) * 60 + 1, I * 60, RSP(), 0, OMITOUT)
            IF AMBIENT(I) < 0 THEN AMBIENT(I) = 0
            PRINT #2, USING O$; I; INDOOR; AMBIENT(I)
        NEXT I
        O2$ = "OVERALL      ####.#         ####.#"
        PRINT #2, "-----------------------------------"
        PRINT #2, USING O2$; Average(1, 1440, RSP(), 0, OMITOUT); Average(1, 24, AMBIENT(), 0, OMITOUT)
        '
        CLOSE #2
        '
END SUB

SUB SaveOptions
'
'** subprogram to save THEM options to a file called THEM.OPT
'**    when program ends
'**  THEM also reads this file before starting
'
        CLS : PRINT "Saving options..."
        '
        CALL OpenFile("THEM.OPT", 8, 0)    'open them.opt for output
        WRITE #8, INFILE$                  'write options to file
        WRITE #8, AMBFILE$
        WRITE #8, POPFILE$
        WRITE #8, TALLYFILE$
        WRITE #8, EXPFILE$
        WRITE #8, ACTFILE$
        WRITE #8, LOCFILE$
        WRITE #8, SMOKFILE$
        WRITE #8, HOURFILE$
        WRITE #8, SCEMFILE$
        WRITE #8, AMBOPT$
        WRITE #8, GROUPOPT$
        WRITE #8, RT1$
        WRITE #8, RT2$
        WRITE #8, RT3$
        WRITE #8, RT4$
        WRITE #8, RT5$
        WRITE #8, RT6$
        WRITE #8, RT7$
        WRITE #8, RT8$
        WRITE #8, RT9$
        WRITE #8, RT10$
        CLOSE #8                             'close them.opt
'
END SUB

SUB SaveProfile (FILENAME$, HEADING$, VECTOR%(), N%)
'
'** sub program to save location/activity vector% for one person to file
'
        DIM OUTFIELD AS STRING * 3
        DIM OUT$
        '
        CALL OpenFile(FILENAME$, 2, 3)     'append file for each person
        '
        PRINT #2, "************************************************************************"
        PRINT #2, HEADING$
        L$ = "Grid of 24 hours vs. 60 minutes per hour"
        L1$ = " HRS- 1     3     5     7     9    11    13    15    17    19    21    23"
        L2$ = "MINS     2     4     6     8    10    12    14    16    18    20    22    24"
        PRINT #2, L$
        PRINT #2, L1$
        PRINT #2, L2$
        PRINT #2, "--|---------------------------------------------------------------------"
        FOR I = 1 TO 60
            OUT$ = ""
            CALL FillString(I, OUTFIELD, OUT$, 3, 3)
```

```
            OUT$ = OUT$ + "="
            FOR J = 1 TO 24
                Value = INT(VECTOR%(I + (J - 1) * 60))
                CALL FillString(Value, OUTFIELD, OUT$, 3, 3)
            NEXT J
            PRINT #2, OUT$
        NEXT I
        PRINT #2, " ": PRINT #2, " "
     '
     CLOSE #2
     '
END SUB

SUB SaveSCEM (HEAD$)
'
'** sub program to save SCEM parameters for each location for each person
'**   gives new set of params for each new smoker location
'
        CALL OpenFile(SCEMFILE$, 2, 3)  'open for append as #2
        '
        PRINT #2, ""
        PRINT #2, "*****************************************************************"
        PRINT #2, "LIST OF SCEM PARAMETERS"
        PRINT #2, ""
        PRINT #2, HEAD$
        PRINT #2, ""
        OA$ = "Room Volume (m3):   ######     Source Strength (ug/cig.): #####"
        OB$ = "Smoking Rate (hr-1): #####     Air Exchange Rate (ACH):  ####.#"
        OC$ = "Smoker Location:       ###     Average Conc. (ug/m3):   #####.#"
        PRINT #2, USING OA$; SCEM.VOLUME; SCEM.SOURCE
        PRINT #2, USING OB$; SCEM.SMRATE; SCEM.ACH
        PRINT #2, USING OC$; SCEM.SMLOC; SCEM.AVECONC
        PRINT #2, "*****************************************************************"
        '
        CLOSE #2
'
END SUB

SUB SaveVector (FILENAME$, HEADING$, VECTOR(), N%)
'
'** sub program to save exposure vector for one person to file
'
        DIM OUTFIELD AS STRING * 3
        DIM OUT$
        '
        CALL OpenFile(FILENAME$, 2, 3)   'append file for each person
        '
        PRINT #2, "*******************************************************************************"
        PRINT #2, HEADING$
        L$ = "Vector grid of 24 hours vs. 60 minutes per hour"
        L1$ = " HRS- 1     3     5     7     9    11    13    15    17    19    21    23"
        L2$ = "MINS     2     4     6     8    10    12    14    16    18    20    22    24"
        PRINT #2, L$
        PRINT #2, L1$
        PRINT #2, L2$
        PRINT #2, "--|----------------------------------------------------------------------"
        FOR I = 1 TO 60
            OUT$ = ""
            CALL FillString(I, OUTFIELD, OUT$, 3, 3)
            OUT$ = OUT$ + "="
            FOR J = 1 TO 24
                Value = INT(VECTOR(I + (J - 1) * 60))
                CALL FillString(Value, OUTFIELD, OUT$, 3, 3)
            NEXT J
            PRINT #2, OUT$
        NEXT I
     '
     PRINT #2, " ": PRINT #2, " "
     CLOSE #2
     '
'
END SUB

SUB SaveWriteActivity (LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP(), AMBIENT())
'
'** subprogram to save profiles and summaries for each person
'
    'Header for all vector prints to file or printer
    '
    HEAD$ = "PERSON # " + STR$(PEOPLE%) + " / PID #" + STR$(LASTPID&) + " / " + INFILE$ + ""
    '
```

```
    '-----------------------------------------
    'Save vectors and profiles to FILE if opted for
    '
    IF ACTFILE$ <> "" THEN
         CALL UpdateScreen("Saving Activites to File")
         CALL SaveProfile(ACTFILE$, "ACTIVITIES FOR " + HEAD$, ACTIVITY%(), 1440)
    END IF
    IF LOCFILE$ <> "" THEN
         CALL UpdateScreen("Saving Locations to File")
         CALL SaveProfile(LOCFILE$, "LOCATION FOR " + HEAD$, LOCATION%(), 1440)
    END IF
    IF SMOKFILE$ <> "" THEN
         CALL UpdateScreen("Saving Smokers to File")
         CALL SaveProfile(SMOKFILE$, "SMOKERS FOR " + HEAD$, SMOKERS%(), 1440)
    END IF
    '
    '-----------------------------------
    'print stuff to PRINTER if opted for
    '
    IF RT10$ = "Yes" THEN PrinterControl "FF"   'advance a page
    IF RT6$ = "Yes" THEN
        CALL UpdateScreen("Printing Profiles to Line Printer")
        CALL PrintProfile("ACTIVITY FOR " + HEAD$, ACTIVITY%())
        CALL PrintProfile("LOCATION FOR " + HEAD$, LOCATION%())
        CALL PrintProfile("SMOKERS FOR " + HEAD$, SMOKERS%())
    END IF
    '
    '-------------------------------------------------
    '** write vectors to SCREEN if opted for
    '
    '
    IF CALCMODE$ = "Detailed" OR RT2$ = "Yes" THEN
        CALL UpdateScreen("Press Any Key for 1440-min. Profiles...")
        SLEEP: CLS
        CALL WriteProfile("ACTIVITY FOR " + HEAD$, ACTIVITY%())
        CALL WriteProfile("LOCATION FOR " + HEAD$, LOCATION%())
        CALL WriteProfile("SMOKING FOR " + HEAD$, SMOKERS%())
        SetUpScreen
    END IF
END SUB

SUB SaveWriteExposure (LOCATION%(), ACTIVITY%(), SMOKERS%(), RSP(), AMBIENT())
'
'** subprogram to save profiles and summaries for each person
'
    'Header for all vector prints to file or printer
    '
    HEAD$ = "PERSON # " + STR$(PEOPLE%) + " / PID #" + STR$(LASTPID&) + " / " + INFILE$ + ""
    '
    '-----------------------------------------
    'Save vectors and profiles to FILE if opted for
    '
    IF EXPFILE$ <> "" THEN
         CALL UpdateScreen("Saving Exposures to File")
         CALL SaveVector(EXPFILE$, "EXPOSURE FOR " + HEAD$, RSP(), 1440)
    END IF
    IF HOURFILE$ <> "" THEN
         CALL UpdateScreen("Saving Hourly Summary to File")
         CALL SaveHourlySum(RSP(), AMBIENT())
    END IF
    '
    '-----------------------------------
    'print stuff to PRINTER if opted for
    '
    IF RT10$ = "Yes" THEN PrinterControl "FF"   'advance a page
    IF RT7$ = "Yes" THEN
        CALL UpdateScreen("Printing Exposures to Line Printer")
        CALL PrintVector("MICROENVIRONMENTAL EXPOSURE FOR " + HEAD$, RSP())
    END IF
    IF RT8$ = "Yes" THEN
        CALL UpdateScreen("Printing Hourly Summary to Line Printer")
        CALL PrintHourlySum(HEAD$, PEOPLE%, RSP(), AMBIENT())
    END IF
    '
    '-------------------------------------------------
    '** write vectors to SCREEN if opted for
    '
    '
    IF CALCMODE$ = "Detailed" OR RT3$ = "Yes" THEN
        CALL UpdateScreen("Press Any Key for Exposures...")
        SLEEP: CLS
```

```
        CALL WriteVector("EXPOSURE FOR " + HEAD$, RSP())
        SetUpScreen
    END IF
    '
    'hourly summary if opted
    '
    IF CALCMODE$ = "Detailed" OR RT5$ = "Yes" THEN
        CALL UpdateScreen("Press Any Key for Hourly Summary....")
        SLEEP: CLS
        CALL WriteHourlySum(RSP(), AMBIENT())
        SetUpScreen
    END IF
    '
    GraphProfile LOCATION%(), SMOKERS%(), RSP(): SLEEP
    SetUpScreen
'
END SUB

FUNCTION SCEMExp (LOCATION%)
'
'** sub program to assign indoor exposures to RSP based on
'** location and smoking activity codes using
'** SCEM (Sequential Cigarette Exposure Model)
'
'** For information on this model please consult the following paper:
'
'  Ott et al, Journal of Exposure Assessment and Environmental Epidemiology,
'  v. 2, s. 2 1992, p. 175-
'
'** The equation on p. 185 for the average RSP due to one smoker is:
'
'    Z =  (Go*F*S)/(PHI*V)  where  Go = source strengh (ug/min)
'                                  F = smoking rate (cig./hr.)
'                                  S = cigarette duration (min./cig.)
'                                  PHI = air exchange rate (ach)
'                                  V = room volume (m3)
'
'SHARED SCEM AS SMPARAMS
        '
        SCEM.ACH = DistSample(EXCHANGE())    'ach
        SCEM.SOURCE = NormSample(NSOURCE())   'ug/cig.
        SCEM.SMRATE = NormSample(NSMRATE())   'cig/hr
        SCEM.SMLOC = LOCATION%
        '
        SELECT CASE LOCATION%
            CASE 1, 3, 4  'house; other indoor; bar/rest
                SCEM.NUMROOMS = DistSample(NUMROOMS())
                SCEM.VOLUME = DistSample(FOOTAGE()) * 10 * .02833 / SCEM.NUMROOMS
            CASE 2  'office/fact
                SCEM.VOLUME = DistSample(FOOTAGE()) * 10 * .02833
            CASE 5  'outdoor
                SCEM.VOLUME = 100000#
            CASE 6  'vehicle
                SCEM.VOLUME = NormSample(NVEHVOL()) * .02833
                WIN% = Die(1)
                IF WIN% = 1 THEN
                    SCEM.ACH = NormSample(NVEHEXCHO())
                ELSEIF WIN% = 0 THEN SCEM.ACH = NormSample(NVEHEXCHC())
                END IF
            CASE ELSE
               SCEM.VOLUME = 100000000
               SCEM.ACH = 1
        END SELECT
        '
        SCEM.AVECONC = (SCEM.SOURCE * SCEM.SMRATE) / (SCEM.ACH * SCEM.VOLUME)
        SCEMExp = SCEM.AVECONC  'set to minute in exp. profile
        '
END FUNCTION

SUB SetUpScreen
'
'** subprogram to set up the screen during calculations of exposure
'   UpdateScreen updates the values and the status bar
'
        TIMES% = 0     'number of times UpdateScreen is called
        '
        COLOR , 0    'black background
        CLS
        PlaceText "CALCULATION INFORMATION AND STATUS", 2, 1, 12
        PlaceText "--Press ESC to CANCEL--", 2, 2, 10
        IF CALCMODE$ = "N" THEN
```

```
            PlaceText "N =" + STR$(NUMBER%) + " Calculation", 2, 3, 15
        ELSE
            PlaceText CALCMODE$ + " Calculation", 2, 3, 15
        END IF
        '
        PRINT : PRINT : RepeatCH "=", 80, 11
        PlaceText "SAMPLED RSP VALUE", 1, 8, 14
        PlaceText "ETS MODEL PARAMETERS", 50, 6, 14
        RepeatCH "-", 45, 11
        RepeatCHV "|", 6, 5, 46, 11
        PlaceText "*MICROENVIRONMENTAL EXPOSURES*", 2, 5, 9
        OA$ = "Source Strength (ug/cig.):"
        OB$ = "   Room Volume (m3):         Air Exchange Rate (ACH):"
        OC$ = "Smoking Rate (hr-1):           Average Conc. (ug/m3):"
        PlaceText OA$, 48, 7, 15
        PlaceText OB$, 21, 8, 15
        PlaceText OC$, 21, 9, 15
        RepeatCHV "|", 2, 8, 19, 11
        PRINT
        RepeatCH "=", 80, 11
        '
        PRINT : PRINT : RepeatCH "=", 80, 11
        PlaceText "*PERSON STATUS*", 2, 12, 9
        PRINT
        O1$ = "              Person ID:              No. Person Records:         "
        PRINT O1$
        O2$ = "          Person Number:              Total Records Read:         "
        PRINT O2$
        PRINT "                     Diary Date (Julian Format) :"
        PlaceText "LAST 24-HR EXPOSURE:", 1, 16, White
        PlaceText "Micro: ", 30, 16, White
        PlaceText "Ambient: ", 50, 16, White
        '
        RepeatCH "=", 80, 11
        PRINT : PRINT : RepeatCH "=", 80, 11
        PlaceText "*CALCULATION STATUS*", 2, 19, 9
        COLOR 10
        LOCATE 24, 1
        RepeatCH "=", 80, 11
        '
END SUB

SUB ShowGroupLoc
'
'** sub program to show regrouped location codes
'
OPT% = 0
WHILE OPT% = 0
    CLS
    PlaceText "Regrouped Location Codes & Corresponding Exposure Calculation Method", 2, 1, Title
    RepeatCH "-", 80, Lin
    FOR I = 1 TO NUMGROUPS%
        GSTR$ = ""
        FOR J = 1 TO LOCAT(I).NGROUP
            GSTR$ = GSTR$ + STR$(LOCAT(I).REGROUP(J))
        NEXT J
        PlaceText STR$(LOCAT(I).CODE) + "  " + LOCAT(I).NAME + " " + LOCAT(I).METHOD + " " + GSTR$, 1, I +
3, Text
    NEXT I
    LOCATE 23, 1
    INPUT "Enter Number of Desired Group Distribution or 0 to quit: ", I%
    IF I% = 0 THEN OPT% = 1
    IF I% > 0 AND I% <= NUMGROUPS% THEN
       CLS
       WriteDist LOCAT(I%).ETSDIST()
       SLEEP
    END IF
    CLS
WEND
END SUB

SUB ShowLocations
'
'** sub program to show location codes
'
        CLS
        PRINT " 1  IN KITCHEN           2  IN LIVING ROOM"
        PRINT " 3  IN DINNING ROOM      4  IN BATHROOM"
        PRINT " 5  IN BEDROOM           6  IN STUDY"
        PRINT " 7  IN GARAGE            8  IN BASEMENT"
        PRINT " 9  IN UTILITY ROOM     10 POOL,SPA"
```

```
        PRINT "11  IN YARD             12 ROOM TO ROOM"
        PRINT "13  OTHER HH ROOM       21 AT OFFICE"
        PRINT "22  AT PLANT            23 AT GROCERY STORE"
        PRINT "24  AT SHOPPING MALL    25  AT SCHOOL"
        PRINT "26  OTHER PUBLIC PLACE  27 AT HOSPITAL"
        PRINT "28  AT RESTAURANT       29 AT BAR-NIGHTCLUB"
        PRINT "30  AT CHURCH           31  AT INDOOR GYM"
        PRINT "32  AT OTHERS HOME      33 AUTO PRINT REPAIR"
        PRINT "34  AT PLAYGROUND       35 AT HOTEL - MOTEL"
        PRINT "36  AT DRY CLEANERS     37  AT BEAUTY PARLOR"
        PRINT "38  AT WORK: MOVING     39  OTHER INDOOR"
        PRINT "40  OTHER OUTDOOR       51  IN CAR"
        PRINT "52  IN VAN              53  WALKING"
        PRINT "54  AT BUS STOP         55  ON BUS"
        PRINT "56  ON RAPID TRAIN      57  OTHER TRUCK"
        PRINT "58  ON AIRPLANE         59  ON BICYCLE"
        PRINT "60  ON MOTORCYCLE       61  OTHER TRANSPORTATION"
        PRINT "99  UNKNOWN LOCATION    Press any key...": SLEEP
END SUB

SUB ShowParamsMenu
'
'** sub program to show calculation parameters/distributions
'
    PARAMOPT% = 0
    CLS
    WHILE PARAMOPT% = 0
        PlaceText "LOCATION CODES AND DISTRIBUTION PARAMETERS", 2, 4, 10
        RepeatCH "-", 80, 13
        PlaceText "L-Standard Location Codes", 28, 6, 11
        PlaceText "R-Regrouped Location Codes & Constant Exposures", 28, 7, 11
        PlaceText "F-House Footage CDF", 28, 8, 11
        PlaceText "A-Air Exchange (ach) CDF", 28, 9, 11
        RepeatCH "-", 80, 13
        'PlaceText "Vehicle ach normal Mean; " + STR$(NVEHEXCH(1)), 28, 12, 11
        'PlaceText "Vehicle ach normal STD: " + STR$(NVEHEXCH(2)), 28, 13, 11
        'RepeatCH "-", 80, 13
        PlaceText "ESC-Return to Previous Menu", 2, 15, 15
        RepeatCH "_", 80, 14
        PlaceText "Press Letter of Parameters to view...", 2, 17, 14
        ROPT$ = GetAKey("")
        PRINT
        SELECT CASE ROPT$
            CASE "l", "L":  ShowLocations   'prints location codes
            CASE "r", "R": CLS : ShowGroupLoc 'print regrouped loc codes
            CASE "f", "F": CLS : PRINT "HOUSE FOOTAGE DISTRIBUTION"
                           PRINT : CALL WriteDist(FOOTAGE()): SLEEP
            CASE "a", "A": CLS : PRINT "AIR EXCHANGE DISTRIBUTION"
                           PRINT : CALL WriteDist(EXCHANGE()): SLEEP
            CASE CHR$(27): PARAMOPT% = 1
            CASE ELSE
        END SELECT
        CLS
    WEND
END SUB

SUB StorePerson (AMBIENT(), RSP())
'
'**  sub program to store exposure data for one person
'
'
        DIM INDOOR(24)
        DIM TOTALRSP(24)
        '
        CALL UpdateScreen("Saving 24-Hour Exposures to File")
        '
        'ug/m3 threshold for determining unexposed people
        THRESH = .5
        '
        AVEEXP = Average(1, 1440, RSP(), 0, OMITOUT)
        AVEAMB = Average(1, 24, AMBIENT(), 0, OMITOUT)
        MAXEXP = Maximum(1440, RSP())
        '
        'Find hourly averages of Personal Indoor Exposure
        '
        FOR I = 1 TO 24
            INDOOR(I) = Average((I - 1) * 60 + 1, I * 60, RSP(), 0, OMITOUT)
            TOTALRSP(I) = INDOOR(I) + AMBIENT(I)
        NEXT I
        '
        TOTMAX = Maximum(24, TOTALRSP())
```

```
        '
        'set code in PERSONDATA for unexposed person if average exposure
        '     is 0 ug/m3
        '
        'exposed people are indicated by a 1
        IF AVEEXP > THRESH THEN PERSONDATA.EXPOS = 1 ELSE PERSONDATA.EXPOS = 0
        '
        'store demographic info.
        PERSONDATA.PID = LASTPID&
        PERSONDATA.AGE = AGE&
        PERSONDATA.SEX = RSEX&
        '
        'save current person 24-hour exposures & maximum exp. to file
'.....................................................................
        OpenFile POPFILE$, 2, 3    'open file #2 for append
        O$ = " #### ##### ## # #  ####.##      ####.##         ####.##       ####.##"
        PRINT #2, USING O$; PEOPLE%; PERSONDATA.PID; PERSONDATA.AGE; PERSONDATA.SEX; PERSONDATA.EXPOS;
AVEEXP; MAXEXP; AVEAMB; TOTMAX
        CLOSE #2
'.....................................................................

        'save tally of number of "exposure hours in each location"
        IF TALLYFILE$ <> "" THEN
           OpenFile TALLYFILE$, 2, 3   'open file #2 for append
           O$ = "  ####  "
           TOT = 0
           PRINT #2, USING O$; PEOPLE%; PERSONDATA.PID;
           FOR I = 1 TO NUMGROUPS%
               PRINT #2, USING O$; LOCAT(I).TALLY;
               TOT = TOT + LOCAT(I).TALLY
           NEXT I
           PRINT #2, USING O$; TOT
        END IF
        '
        CLOSE #2
'.....................................................................

'.....................................................................
        'Pause if opted
        '
        IF RT4$ = "Yes" THEN
            CALL UpdateScreen("Press Any Key to Start Next Person...")
            SLEEP
        END IF
        '
END SUB

SUB UpdateScreen (STATUS$)
'
'** sub program to update to the screen the progress of the calculation
'-----------------------------------------------------------------------
'  Update-Screen Codes are as follows:
'
'    Major Task Announcements
'       1 - Read Activity Data for Person;    2 - Read Ambient Data
'       3 - Create 1440-minute Profiles;      4 - Calculate Micro. Exp.
'       5 - Smoker Present in: ??????         6 - Saving 24-hour exposures
'    Input/Output Status
'       11 - Press any key for profiles      12 - Press any key for exp...
'       13 - Press any key for hour sum...   14 - Printing profiles....
'       15 - Printing exposures....          16 - Printing hourly sum...
'       17 - Saving profiles...              18 - Saving exposures....
'       19 - Saving hourly sum...
'       20 - Press any key to return to Main Menu...
'     Misc.
'       30 - UPDATE LOCATION LEGEND
'       33 - UPDATE ACTIVITY LEGEND
'-----------------------------------------------------------------------
        TIMES% = TIMES% + 1
        '
        COLOR , 0    'black background
        COLR% = 10
        S1% = 45      'Status X coord.
        S2% = 34      'Status Y coord.
              IF CURRENTSMOK% = 1 AND LOCAT(CURRENTLOC%).EXCLUDE <> "X" THEN PlaceText "Smoker Present: " +
LOCAT(CURRENTLOC%).NAME + "(" + LOCAT(CURRENTLOC%).METHOD + ")", 1, 6, COLR%
              IF LOCAT(CURRENTLOC%).METHOD = "MICR" THEN
                 IF CURRENTLOC% < 1 OR CURRENTLOC% > 100 THEN CURRENTLOC% = 1
                 PlaceNumber LOCAT(CURRENTLOC%).SAMPLE, "#### (ug/m3)", 1, 9, COLR%
                 PRINT : PRINT : PRINT : PRINT
              ELSE
```

```
                PlaceNumber SCEM.SOURCE, "######", 75, 7, COLR%
                PlaceNumber SCEM.VOLUME, "######", 41, 8, COLR%
                PlaceNumber SCEM.ACH, "###.#", 76, 8, COLR%
                PlaceNumber SCEM.SMRATE, "##.#", 43, 9, COLR%
                PlaceNumber SCEM.AVECONC, "#####.#", 74, 9, COLR%
             END IF
             PlaceNumber AVEEXP, "#####.##", 36, 16, COLR%
             PlaceNumber AVEAMB, "#####.##", 60, 16, COLR%
       '
             PlaceLong PID&, "#######", 27, 13, COLR%
             PlaceLong RECPERSON&, "####", 63, 13, COLR%
             PlaceInteger PEOPLE%, "#######", 27, 14, COLR%
             PlaceLong RECTOTAL&, "#######", 60, 14, COLR%
             PlaceNumber DATE, "#####", 55, 15, COLR%
       '
       COLOR 10
       SELECT CASE TIMES%
          CASE 1: LOCATE 20, 1:
                     RepeatCH " ", 80, 0: RepeatCH " ", 80, 0:
                     RepeatCH " ", 80, 0: RepeatCH " ", 80, 0:
                     COLOR 11: LOCATE 20, 1
          CASE 2: COLOR 12: LOCATE 20, 42
          CASE 3: COLOR 13: LOCATE 21, 1
          CASE 4: COLOR 14: LOCATE 21, 42
          CASE 5: COLOR 15: LOCATE 22, 1
          CASE 6: COLOR 10: LOCATE 22, 42
          CASE 7: COLOR 11: LOCATE 23, 1
          CASE 8: COLOR 4: LOCATE 23, 42: TIMES% = 0
          CASE ELSE
               COLOR 10: LOCATE 20, 1
       END SELECT
       PRINT STATUS$
END SUB

SUB UpdateScreen2 (STATUS$)
'
'** sub program to update to the screen the progress of the calculation
'-------------------------------------------------------------------------
'  Update-Screen Codes are as follows:
'
'    Major Task Announcements
'       1 - Read Activity Data for Person;    2 - Read Ambient Data
'       3 - Create 1440-minute Profiles;      4 - Calculate Micro. Exp.
'       5 - Smoker Present in: ??????         6 - Saving 24-hour exposures
'    Input/Output Status
'       11 - Press any key for profiles      12 - Press any key for exp...
'       13 - Press any key for hour sum...   14 - Printing profiles....
'       15 - Printing exposures....          16 - Printing hourly sum...
'       17 - Saving profiles...              18 - Saving exposures....
'       19 - Saving hourly sum...
'       20 - Press any key to return to Main Menu...
'     Misc.
'       30 - UPDATE LOCATION LEGEND
'       33 - UPDATE ACTIVITY LEGEND
'-------------------------------------------------------------------------
       TIMES% = TIMES% + 1
       '
       COLOR , 0    'black background
       COLR% = 10
       S1% = 45      'Status X coord.
       S2% = 34      'Status Y coord.
       '
       SELECT CASE CODE%
           CASE 1  'read person
             PlaceLong PID&, "#######", 27, 13, COLR%
             PlaceLong RECPERSON&, "####", 63, 13, COLR%
             PlaceInteger PEOPLE%, "#######", 27, 14, COLR%
             PlaceLong RECTOTAL&, "#######", 60, 14, COLR%
             PlaceNumber DATE, "#####", 55, 15, COLR%
           CASE 2  'ambient
             PlaceText "Reading Ambient Data", S1%, S2%, Yellow
           CASE 3  'profiles
             PlaceText "Creating 1440-minute Profiles", S1%, S2%, Yellow
           CASE 4  'calc exposure
             PlaceText "Calculating Microenvironmental Exposures", S1%, S2%, Yellow
           CASE 5  'Smoker Present:
             IF CURRENTSMOK% = 1 AND LOCAT(CURRENTLOC%).EXCLUDE <> "X" THEN PlaceText "Smoker Present: " +
LOCAT(CURRENTLOC%).NAME + "(" + LOCAT(CURRENTLOC%).METHOD + ")", 1, 6, COLR%
             IF LOCAT(CURRENTLOC%).METHOD = "MICR" THEN
                IF CURRENTLOC% < 1 OR CURRENTLOC% > 100 THEN CURRENTLOC% = 1
                PlaceNumber LOCAT(CURRENTLOC%).SAMPLE, "#### (ug/m3)", 1, 9, COLR%
```

```
               PRINT : PRINT : PRINT : PRINT
            ELSE
               PlaceNumber SCEM.SOURCE, "######", 75, 7, COLR%
               PlaceNumber SCEM.VOLUME, "######", 41, 8, COLR%
               PlaceNumber SCEM.ACH, "###.#", 76, 8, COLR%
               PlaceNumber SCEM.SMRATE, "##.#", 43, 9, COLR%
               PlaceNumber SCEM.AVECONC, "#####.#", 74, 9, COLR%
            END IF
          CASE 6  'save 24-h exposures
            PlaceText "Saving 24-hour Exposures to File", S1%, S2%, Yellow
            PlaceNumber AVEEXP, "LAST EXPOSURE:  #####.##", 10, 16, COLR%
            PlaceNumber AVEAMB, "LAST AMBIENT:  #####.##", 45, 16, COLR%
          CASE 11: PlaceText "Saving Profiles", S1%, S2%, Yellow
          CASE 12: PlaceText "Saving Exposures", S1%, S2%, Yellow
          CASE 13: PlaceText "Saving Hourly Summary", S1%, S2%, Yellow
          CASE 14: PlaceText "Printing Profiles", S1%, S2%, Yellow
          CASE 15: PlaceText "Printing Exposures", S1%, S2%, Yellow
          CASE 16: PlaceText "Printing Hourly Summary", S1%, S2%, Yellow
          CASE 17: PlaceText "Press any key for Profiles...", S1%, S2%, Yellow
          CASE 18: PlaceText "Press any key for Exposures...", S1%, S2%, Yellow
          CASE 19: PlaceText "Press any key for Hourly Summary...", S1%, S2%, Yellow
          CASE 20: PlaceText "Press any key for Main Menu...", S1%, S2%, Yellow
          CASE 30: 'location legend

          CASE 31: 'activity legend
          CASE ELSE
        END SELECT
        '
EXIT SUB
'        PlaceText LOCAT(CURRENTLOC%).NAME, 27, 13, COLR%
'        PlaceInteger CURRENTACT%, "###", 64, 13, COLR%
        COLOR 10
        SELECT CASE TIMES%
           CASE 1: LOCATE 20, 1:
                     RepeatCH " ", 80, 0: RepeatCH " ", 80, 0:
                     RepeatCH " ", 80, 0: RepeatCH " ", 80, 0:
                     COLOR 11: LOCATE 20, 1
           CASE 2: COLOR 12: LOCATE 20, 42
           CASE 3: COLOR 13: LOCATE 21, 1
           CASE 4: COLOR 14: LOCATE 21, 42
           CASE 5: COLOR 15: LOCATE 22, 1
           CASE 6: COLOR 10: LOCATE 22, 42
           CASE 7: COLOR 11: LOCATE 23, 1
           CASE 8: COLOR 4: LOCATE 23, 42: TIMES% = 0
           CASE ELSE
                COLOR 10: LOCATE 20, 1
        END SELECT
        PRINT STATUS$
END SUB

SUB WriteDist (VECTOR())
'** sub program to print out distribution vectors of length N%
'** vectors must have form VECTOR(2, N%)
'
    COLOR Green
    L1$ = "   RANGE          CDF"
    L2$ = "------------------------"
    O$ = "######.####       #.###"
    PRINT L1$: PRINT L2$
'
    TEST = 0
    I = 0
    DO UNTIL TEST = 99
        I = I + 1
        TEST = VECTOR(1, I)
        IF TEST <> 99 THEN PRINT USING O$; VECTOR(1, I); VECTOR(2, I)
    LOOP
    PRINT : PRINT "Press any key..."
'
END SUB

SUB WriteHourlySum (RSP(), AMBIENT())
'
'** subprogram for printing to the screen the hourly summary of exposures
'
        COLOR Green
        PRINT "SUMMARY OF AVERAGE HOURLY EXPOSURE (ug/m3)"
        PRINT "         OVER A 24-HOUR PERIOD"
        PRINT
        PRINT "  TIME         INDOOR         AMBIENT"
        PRINT "---------------------------------------"
```

```
        O$ = " ##:00        ####.#         ####.#"
        FOR I = 1 TO 24
            INDOOR = Average((I - 1) * 60 + 1, I * 60, RSP(), 0, OMITOUT)
            IF AMBIENT(I) < 0 THEN AMBIENT(I) = 0
            PRINT USING O$; I; INDOOR; AMBIENT(I)
            SELECT CASE (I / 18)
               CASE 1, 2: SLEEP: ANS$ = INKEY$
            END SELECT
        NEXT I
        O2$ = "OVERALL       ####.#         ####.#"
        PRINT "-----------------------------------"
        PRINT USING O2$; Average(1, 1440, RSP(), 0, OMITOUT); Average(1, 24, AMBIENT(), 0, OMITOUT)
        PRINT "Press any key to continue...": SLEEP
'
END SUB

SUB WriteProfile (HEADING$, VECTOR%())
'
'** sub program to save exposure/activity vector% for one person to file
'
        COLOR Green
        DIM OUTFIELD AS STRING * 3   'field for numbers
        DIM OUT$   'variable length string for line output
        '
        PRINT "****************************************"
        PRINT HEADING$
        L$ = "Grid of 24 hours vs. 60 minutes per hour"
        L1$ = " HRS- 1     3     5     7     9    11    13    15    17    19    21    23"
        L2$ = " MINS    2     4     6     8    10    12    14    16    18    20    22    24"
        PRINT L$
        PRINT L1$
        PRINT L2$
        PRINT "--|------------------------------------------------------------------------------"
        FOR I = 1 TO 60
            OUT$ = ""
            CALL FillString(I, OUTFIELD, OUT$, 3, 3)
            OUT$ = OUT$ + "="
            FOR J = 1 TO 24
                Value = INT(VECTOR%(I + (J - 1) * 60))
                CALL FillString(Value, OUTFIELD, OUT$, 3, 3)
            NEXT J
            PRINT OUT$
            SELECT CASE (I / 18)
               CASE 1, 2: SLEEP: ANS$ = INKEY$
            END SELECT
        NEXT I
        SLEEP
'
END SUB

SUB WriteVector (HEADING$, VECTOR())
'
'** sub program to save exposure/activity vector for one person to file
'**  currently rounds off values to integers
'
        COLOR Green
        DIM OUTFIELD AS STRING * 3
        DIM OUT$
        '
        PRINT HEADING$
        L$ = "Vector grid of 24 hours vs. 60 minutes per hour"
        L1$ = " HRS- 1     3     5     7     9    11    13    15    17    19    21    23"
        L2$ = "MINS     2     4     6     8    10    12    14    16    18    20    22    24"
        PRINT L$
        PRINT L1$
        PRINT L2$
        PRINT "--|------------------------------------------------------------------------------"
        FOR I = 1 TO 60
            OUT$ = ""
            CALL FillString(I, OUTFIELD, OUT$, 3, 3)
            OUT$ = OUT$ + "="
            FOR J = 1 TO 24
                Value = INT(VECTOR(I + (J - 1) * 60))
                CALL FillString(Value, OUTFIELD, OUT$, 3, 3)
            NEXT J
            PRINT OUT$
            SELECT CASE (I / 18)
               CASE 1, 2: SLEEP: ANS$ = INKEY$
            END SELECT
        NEXT I
        SLEEP
```

```
'
END SUB

'------------------------
SUB WriteVectors (LOCATION%(), SMOKERS%(), INDRSP!(), AMBIENT()) STATIC
     PRINT : PRINT "TIME, LOCATION, SMOKERS, RSP EXPOSURE"
     FOR I = 1 TO 1440
        PRINT I, LOCATION%(I), SMOKERS%(I), INDRSP(I), AMBIENT(I)
        '
        pause% = I / 21
        IF I / 21 - pause% = 0 THEN
            SLEEP: ANS$ = INKEY$
        END IF
        '
     NEXT I
END SUB
```