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USER'S GUIDE TO CTDMPLUS:
VOLUME 2. THE SCREENING MODE (CTSCREEN)
(Abridged)

by

Steven G. Perry[*]
Atmospheric Sciences Modeling Division
Air Resources Laboratory
National Oceanic and Atmospheric Administration
Research Triangle Park, NC 27711

Donna J. Burns
Computer Sciences Corporation
Research Triangle Park, NC 27709

Alan J. Cimorelli
Region III, U.S. Environmental Protection Agency
Philadelphia, PA 19107

[*] On assignment to the Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency.

ATMOSPHERIC RESEARCH AND EXPOSURE ASSESSMENT LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

NOTICE

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PREFACE TO THE ABRIDGED VERSION OF THE CTSCREEN USER'S GUIDE

This abridged version of the User's Guide to CTDMPLUS: Volume 2. The Screening Mode (CTSCREEN) has been created for users of the Support Center for Regulatory Air Models Bulletin Board System (SCRAM BBS). It is stored in WordPerfect format on the SCRAM BBS in the Regulatory Models Section under Documentation.

Some portions of the original User's Guide, notably Section 3.4 and the appendices, have been omitted to save space. Section 3.4 contains diagrams of the CTSCREEN subroutine structure. Appendix A contains comparisons between CTSCREEN and other regulatory models. Apendix B contains the input and output from a sample run of the model. Nothing was omitted that is needed by the user to run the model. Users are strongly encouraged to obtain the complete user's guide from NTIS. Ordering information can be found on the SCRAM BBS.

Note that the actual page numbers in your copy of the document may differ from those indicated in the Table of Contents, depending on the kind of printer (as well as the available type font) that is used to print your copy of this document.

ABSTRACT

The EPA's Technology-Transfer Workgroup has developed a screening version (denoted as CTSCREEN) of the Complex Terrain Dispersion Model, CTDMPLUS. CTSCREEN uses an array of predetermined meteorological conditions to model the user supplied source-terrain configuration. CTSCREEN yields estimates of maximum 1-h, 3-h, 24-h, and annual impacts that are conservative with respect to CTDMPLUS estimates using a full year of on-site data. In comparison with other complex terrain screening models, CTSCREEN provides estimates that most consistently reflect those of CTDMPLUS.

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SECTION 1

INTRODUCTION

The Complex Terrain Dispersion Model (CTDMPLUS) is a refined air quality model for use in all atmospheric stabilities with sources located in or near complex topography. Since the model accounts for the three-dimensional nature of plume and terrain interaction, it requires detailed terrain and meteorological data that are representative of the modeling domain. Although the terrain data may be readily obtained from topographic maps and digitized for use in the CTDMPLUS, the required meteorological data may not be as readily available.

Since the meteorological input requirements of the CTDMPLUS can limit its application, the EPA's Complex-Terrain-Modeling, Technology-Transfer Workgroup developed a methodology to use the advanced techniques of CTDMPLUS in situations where on-site meteorological measurements are limited or unavailable. This approach uses CTDMPLUS in a "screening" mode--actual source and terrain characteristics are modeled with an extensive array of predetermined meteorological conditions.

This CTDMPLUS screening mode (CTSCREEN) serves several purposes in regulatory applications. When meteorological data are unavailable, CTSCREEN can be used to obtain conservative (safely above those of refined models), yet realistic, impact estimates for particular sources. These estimates can be used to determine the necessity and value of obtaining on-site data for refined modeling or can simply provide conservative emission-limit estimates. In addition, CTSCREEN can be a valuable tool for designing meteorological and pollutant monitoring programs.

It is important to note that CTSCREEN and the refined model, CTDMPLUS, are the same basic model. The primary difference in their make-up is in the way in which CTSCREEN obtains the meteorological conditions. For example, wind direction in CTSCREEN is calculated based on the source-terrain-dividing streamline geometry to ensure computation of the highest impacts that are likely to occur. The daytime mixed layer heights are based on fractions of the terrain height. Other meteorological variables or parameters are chosen through a variety of possible combinations from a predetermined matrix of values.

CTSCREEN yields maximum concentration estimates that are near to, yet on the conservative side of, those that would result from the use of the CTDMPLUS with a full year of on-site meteorological data for the same source-terrain configuration. Several options are available to the CTSCREEN user so that impacts from multiple sources and multiple terrain features can be obtained with both internally-computed and user-specified wind directions. Model output includes estimates of maximum 1-h, 3-h, 24-h, and annual impacts.

This document is intended as a supplemental guide to the CTDMPLUS user's guide, Volume 1 (Perry et al. 1989). Where not otherwise noted or instructed in this document, the user is to follow the guidance contained in Volume 1. This document provides descriptions of: the meteorological matrices and the internal computation of certain variables, user input options, special user instructions for CTSCREEN, comparisons between the CTDMPLUS, CTSCREEN, COMPLEX I, and VALLEY models for a variety of source-terrain geometries, and examples of model output.

SECTION 2

TECHNICAL DESCRIPTION

The CTSCREEN model has the same technical basis as the CTDMPLUS model as described by Perry et al. (1989). No repetition of this information is needed here. Both models yield identical 1-h estimates for the same meteorological conditions. The differences are in the manner in which the models obtain the meteorological inputs. The user supplies the terrain, source, and receptor information identically in both. For input to CTDMPLUS, meteorological data are collected on site and provided by the user and through the meteorological preprocessor. With CTSCREEN, no user input is required with reference to the meteorology (however, the user is provided the option to select specific wind directions in addition to those selected by CTSCREEN). Without the requirement for meteorological data collection, CTSCREEN is available for application on any source of pollutant for which CTDMPLUS is applicable.

2.1 CTSCREEN METEOROLOGICAL INPUTS

CTDMPLUS was first developed as the CTDM model which was only applicable to stable and neutral atmospheric conditions. The model's applicability was later extended to include daytime convective conditions. Because of the distinction between the modeling methodologies used in the stable/neutral versus the unstable/convective algorithms, the combinations of meteorological parameters required for each were developed separately for CTSCREEN. To select the meteorology, the workgroup focused its efforts on analyses of model sensitivities, typical distributions of meteorological conditions, and the ranges of conditions associated with high concentrations at actual field monitoring sites.

2.1.1 CTSCREEN for Stable/Neutral Conditions

CTSCREEN distinguishes between stable/neutral and convective conditions based on the value of the Monin-Obukhov length, L , and the mixed layer height, z_i. If L is positive or if $L < -100$ (and $L < 10$) then CTSCREEN assumes the plume is transported and diffused in a stable or neutral layer. The matrix of meteorological values selected to represent stable/neutral conditions is based on an analysis of:

(1) sensitivity tests of the model to the individual input variables, (2) ten months of meteorological conditions observed at the Full Scale Plume Study Tracy site (Truppi 1986), and (3) a full year of data from the Widow's Creek monitoring study (Egan et al. 1985).

The stable/neutral algorithms of CTSCREEN require the following meteorological variables to compute concentrations:

U -- wind speed at plume height (m/s)
σ_v -- standard deviation of the lateral wind speed (m/s)
σ_w -- standard deviation of the vertical wind speed (m/s)
$d\Theta/dz$ -- vertical potential temperature gradient (K/m)
WD -- wind direction

The remaining meteorological inputs such as mixing height, surface roughness, friction velocity, and the Monin-Obukhov length need not be specified for the stable/neutral CTSCREEN since they only have a bearing on the vertical scaling of meteorological variables to plume height. The nature of CTSCREEN preempts the need for vertical scaling. The variables are simply assumed constant with height and the highest input level is set well above any stack or plume heights. Stack top temperature is defaulted to 293 K for all cases.

After examination of the five variables (above) through sensitivity tests and analysis of field data, a matrix of values (Table 2-1) was determined to adequately portray the conditions associated with "worst case" impacts.

This matrix of meteorology (with exceptions) results in 96 combinations to pass through the CTSCREEN model for each calculated or user-specified wind direction.

Wind direction in CTSCREEN is determined in an automated way. This is necessary because the geometry between the source and the fitted hill shape at the dividing streamline level, Hcrit, (Snyder et al. 1985) greatly influences the optimum (yielding highest impacts) wind direction. This geometry changes as each combination of meteorology yields a different Hcrit, plume height, and cutoff hill height. So, with simple coding changes to CTDMPLUS, CTSCREEN computes the optimum wind direction for each combination of other meteorological variables in the matrix. The following describes the method used for single-source/single-terrain cases. The extension to multiple-source/multiple-terrain feature cases is discussed later.

TABLE 2-1. NEUTRAL/STABLE METEOROLOGICAL MATRIX

Variable	Specified Values				
U (m/s)	1.0	2.0	3.0	4.0	5.0
σ_v (m/s)	0.3	0.75			
σ_w (m/s)	0.08	0.15	0.30	0.75	
$d\Theta/dz$ (K/m)	0.01	0.02	0.035		

Exceptions:

(1) If $U \leq 2$ m/s and σ_v= 0.3 m/s, then include σ_w= 0.04 m/s in the matrix.

(2) If σ_w= 0.75 m/s and $U \geq 3.0$ m/s, then $d\Theta/dz$ is limited to 0.01 K/m.

(3) If $U \geq 4$ m/s, then $\sigma_w \geq 0.15$ m/s.

(4) $\sigma_w \leq \sigma_v$

For each combination of conditions in the matrix above (96 cases) the model determines the plume height and Hcrit (dividing streamline height) as in CTDMPLUS. Depending on the relationship between the plume height and Hcrit, the wind direction is determined in one of three ways.

1. **For Hplume < Hcrit**: If the plume center is below Hcrit, the maximum concentration is controlled by the WRAP calculation (see Perry et al. 1989 for a discussion of the WRAP and LIFT calculations, Hcrit, and the stagnation streamline). The CTDMPLUS code has been modified to calculate the first guess wind direction as the direction from the source to the center of the ellipse selected by the model for the WRAP calculation. With this WD, the model calculates the distance, *d*, between the source streamline and the stagnation streamline. Minimizing *d* maximizes the surface concentration estimate. If *d* is greater than 10 m, the model calculates the *d* value for wind directions up to plus or minus 30° from the first guess direction. The iterations begin with increments of five degrees and focus eventually to one degree. The optimum (minimum *d*) direction is then used to continue the computations for the selected meteorological conditions.

2. **For Hplume > Hcrit and large [Hplume - Hcrit]**: If the plume is well above Hcrit, then the maximum concentration will be determined by a LIFT calculation since WRAP will have little impact. It is the "cutoff hill" that influences the flow distortion in this case. Therefore, the optimum wind direction is selected as that along a line from the source to the center of the cutoff hill, determined automatically by the model. Tests have shown that this produces the highest concentrations for a plume well above Hcrit. Computations then continue with this wind direction.

3. **For Hplume > Hcrit, but small [Hplume - Hcrit]**: When the plume height is above Hcrit but such that a significant portion of the plume is still below Hcrit, then the receptors above Hcrit can receive significant concentrations from LIFT and WRAP. For these particular cases, the model determines the wind direction from both methods 1 and 2 and calculates the maximum concentration with each. The highest of the maximum concentrations from these two approaches is saved. The [Hplume - Hcrit] value where both LIFT and WRAP have significant impacts on the maximum concentrations depends on the vertical size of the plume at the point of impaction. The value of [Hplume - Hcrit] below which method 3 is used has been set to $\sigma_z/3$ (where is calculated at the impaction point).

Since the computations that are made to determine the optimum wind direction are performed outside the receptor loop, this method of specifying wind direction produces conservative concentration estimates with very little impact on the overall execution time for CTSCREEN.

2.1.2 CTSCREEN for Unstable/Convective Conditions

This section describes the meteorological variables used with CTSCREEN that represent conditions when convection is important ([$-100 < L < 0$ or $-z_i/L > 10$] and stack height < z_i). This set of values is based on an analysis of:

- meteorology associated with highest observed concentrations during eleven months of daytime conditions (that meet the above criteria) at the Westvaco site (Wackter and Londergan, 1984);
- meteorology associated with the highest CTDMPLUS predicted concentrations during the same daytime conditions at Westvaco; and
- sensitivity tests on CTDMPLUS for the important meteorological inputs to the model.

The daytime (convective) algorithms of CTSCREEN require the following meteorological variables to compute concentrations:

U	-- wind speed at half plume height (m/s)
z_i	-- mixing height (m)
u_*	-- friction velocity (m/s)
L	-- Monin-Obukhov length (m)
$d\Theta/dz$	-- potential temperature gradient above (K/m)
WD	-- wind direction at half plume height
θ	-- ambient potential temperature at (K)
T	-- ambient temperature at stack height (K)

Model-calculated wind direction is based on plume-hill geometry using method 2 of the stable/neutral case and assuming Hcrit is zero. Users also may specify discrete wind directions. Potential temperature at the mixed layer top and temperature at the stack top are both calculated internally by the model. CTSCREEN assumes a temperature of 293 K at the first tower level and extrapolates vertically with an assumed mixed layer $d\Theta/dz = 0$ ($dT/dz = -0.0098$ K/m).

This leaves five meteorological variables to include in the "daytime" matrix: U, z_i, u_*, L, and $d\Theta/dz$ (above z_i). After examination of these five variables through sensitivity tests and analysis of field data, the matrix of values in Table 2-2 was determined to adequately portray the convective conditions associated with maximum impacts as estimated by CTDMPLUS.

TABLE 2-2. UNSTABLE/CONVECTIVE METEOROLOGICAL MATRIX

Variable	Specified Values			
U (m/s)	1.0	2.0	4.0	6.0
u_* (m/s)	0.1	0.3	0.5	
L (m)	-10	-50	-90	
$d\Theta/dz$ (K/m)	0.030			
z_i (m)	0.5 h	1.0 h	1.5 h	

(where h = terrain height)

This matrix yields 108 combinations (simulations with the model) for each wind direction. When added to the stable/neutral cases, the total number of simulations is 204 (per wind direction) for each source/terrain combination. This requires a very reasonable execution time.

2.2 MULTIPLE SOURCES AND TERRAIN FEATURES

The above methodology considers the case of a single source and single terrain feature. Often, the user of CTSCREEN is concerned about multiple sources and multiple terrain features. A generic procedure, designed to guarantee the determination of worst-case combined impacts from multiple sources,would require a prohibitively large number of simulations. Therefore, the workgroup decided thatmulti-source screening procedures would be handled on a case-by-case basis with the following options made available to the user to ensure effective implementation and provide adequate flexibility.

- The model automatically calculates the maximum impact from any selected combination of the sources based on the optimum wind directions determined for each individual source. The user may designate sources as primary or secondary; optimum wind directions are determined only for these primary sources; however, all sources are included in the impacts estimates.

- The user also has the option to have CTSCREEN calculate maximum impacts with wind directions determined as the average of any pair of individual optimum wind directions. Often it is some wind direction between the optimum directions that is associated with the maximum combined impacts of two or more sources.

- The user is also able to specify a range (and increment) of wind directions over which to calculate maximum impacts. Often there is a large number of primary sources in one general area. The specification of wind direction over a given range (with adequate resolution within the range) may be more appropriate for finding maximum combined impacts than would a large number of automatically determined wind directions.

- To allow maximum flexibility, the user is given the option to specify up to 50 discrete wind directions.

- Any combination of the above.

With the aid of these modeling options, the users are able to design the needed multi-source scenarios that insure conservative application of CTSCREEN, yet limit the total number of required simulations. Users should be judicious in the selection of these options, since--for options 1 and 2--the number of simulations increases greatly over the single-source / single-terrain case even when the number of primary sources is moderate. For example, with four primary sources and two terrain features, the selection of options 1 and 2 result in up to 4,100 simulations. For single-source cases (with one or more terrain features), option two should be chosen.

2.3 AVERAGING BEYOND ONE HOUR

Although CTSCREEN calculates maximum 1-h impacts at all receptor locations, it is designed to provide conservative estimates of worst case 3-h and 24-h highest-second-high (HSH) and annual impacts. A number of options for converting 1-h estimates to 3-h and 24-h HSH and annual estimates were considered by the Technology-Transfer Workgroup, and it was decided that the only workable approach would be to use simple scaling factors. The workgroup used the results of a comparison study between CTSCREEN and CTDMPLUS to select appropriate factors for conversion from 1-h to 3-h HSH, from 1-h to 24-h HSH, and from 1-h to annual estimates of worst case impacts. The study included a wide variety of source and terrain types and source/terrain configurations (described in Appendix A (note: Appendix A omitted)).

Figure 2-1 displays the ratios of CTDMPLUS 3-h HSH values to CTSCREEN 1-h highest for the 22 scenarios (see Appendix A (note: Appendix A omitted) for a description of scenarios tested). In all but two cases (both involving Montour Ridge, alongwind orientation), the ratio is less than 0.7. The workgroup felt that the Montour alongwind cases represent situations that are encountered infrequently. Therefore, without further analysis of these extreme cases, the group selected an otherwise highly conservative conversion factor of 0.7 to convert CTSCREEN 1-h maxima to 3-h HSH estimates.

Similarly, Figure 2-2 shows the ratios of CTDMPLUS 24-h HSH to CTSCREEN 1-h maxima. Again, with appropriate consideration to the Montour alongwind cases, the workgroup concluded that a conversion factor of 0.15 would be sufficiently conservative.

Finally, Figure 2-3 shows the ratios of CTDMPLUS annual estimates to CTSCREEN 1-h highest. Based on these results, a conservative conversion factor of 0.03 was selected by the workgroup.

These three fixed conversion factors are built into the CTDMPLUS code for cases when the CTSCREEN mode is selected. In this way, the 1-h,3-h,24-h, and annual screening estimates appear in the output file. Comparisons of CTSCREEN estimates (based on these factors) with those of the COMPLEX I and VALLEY models are discussed in Appendix A (note: Appendix A omitted).

2.4 IMPLEMENTATION OF CTSCREEN

CTSCREEN should be used under the same technical guidance as the CTDMPLUS. This document should be used in conjunction with the CTDMPLUS user's guide, Volume 1 (Perry et al. 1989) and the terrain preprocessor user's guide (Mills et al. 1987). CTSCREEN simply eliminates the need to prepare the three meteorological input files SURFACE, PROFILE, and RAWIN. All other input files should be prepared by the user, in accordance with the CTDMPLUS user's manual Volume 1, based on actual source and terrain characteristics. Since a number of parameters such as wind direction are calculated automatically in CTSCREEN, a special version of the CTDMPLUS code was developed with options to run the CTSCREEN mode.

It is important to note that CTSCREEN model yields identical 1-h concentration estimates to that of the refined CTDMPLUS for the same meteorological conditions. The conservative nature of CTSCREEN results from the use of a carefully selected range of meteorological conditions and appropriate conversions to 3-h HSH, 24-h HSH, and annual high estimates.

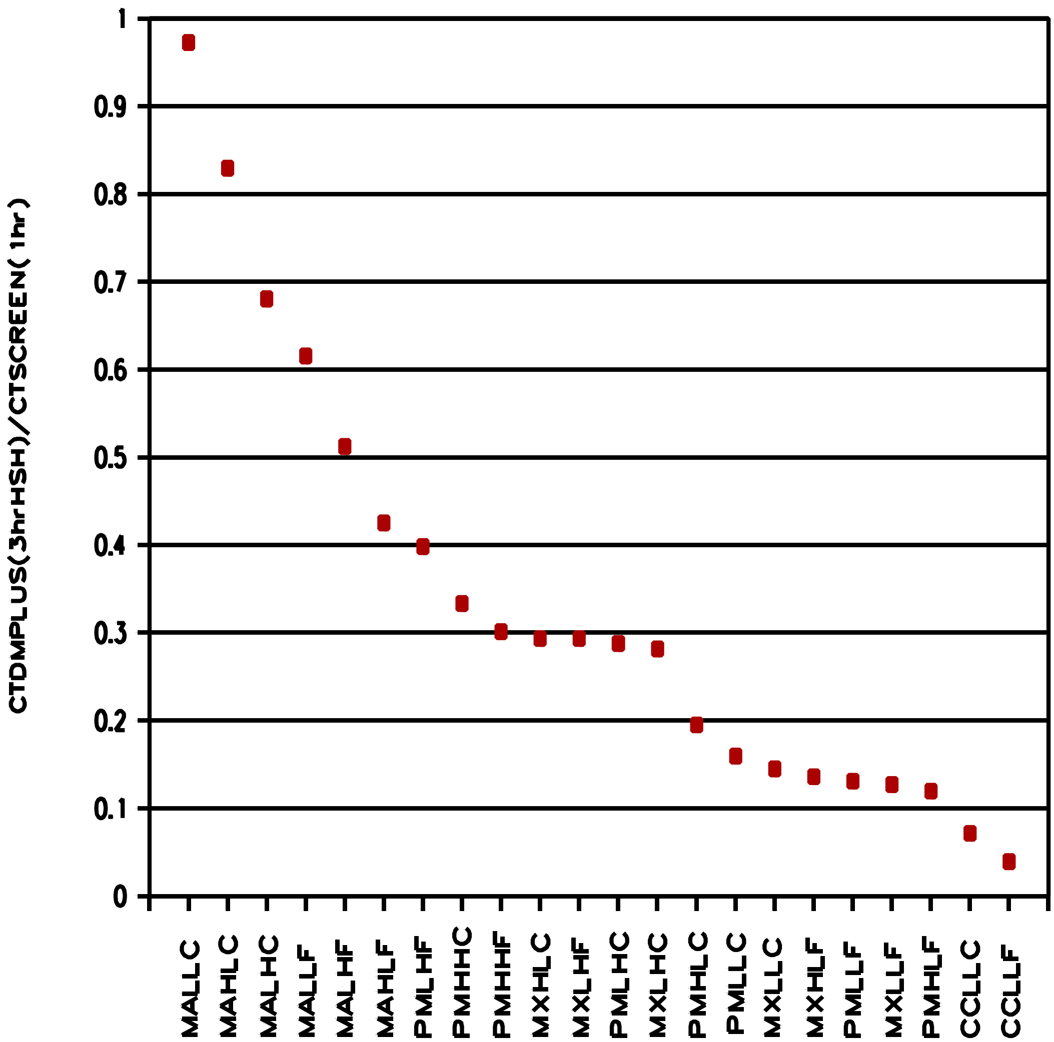

Figure 2-1. CTDMPLUS (3-h HSH)/CTSCREEN (1-h) concentrations for the 22 different source-hill combinations. (See Table A-1 for explanation of abscissa notation.)

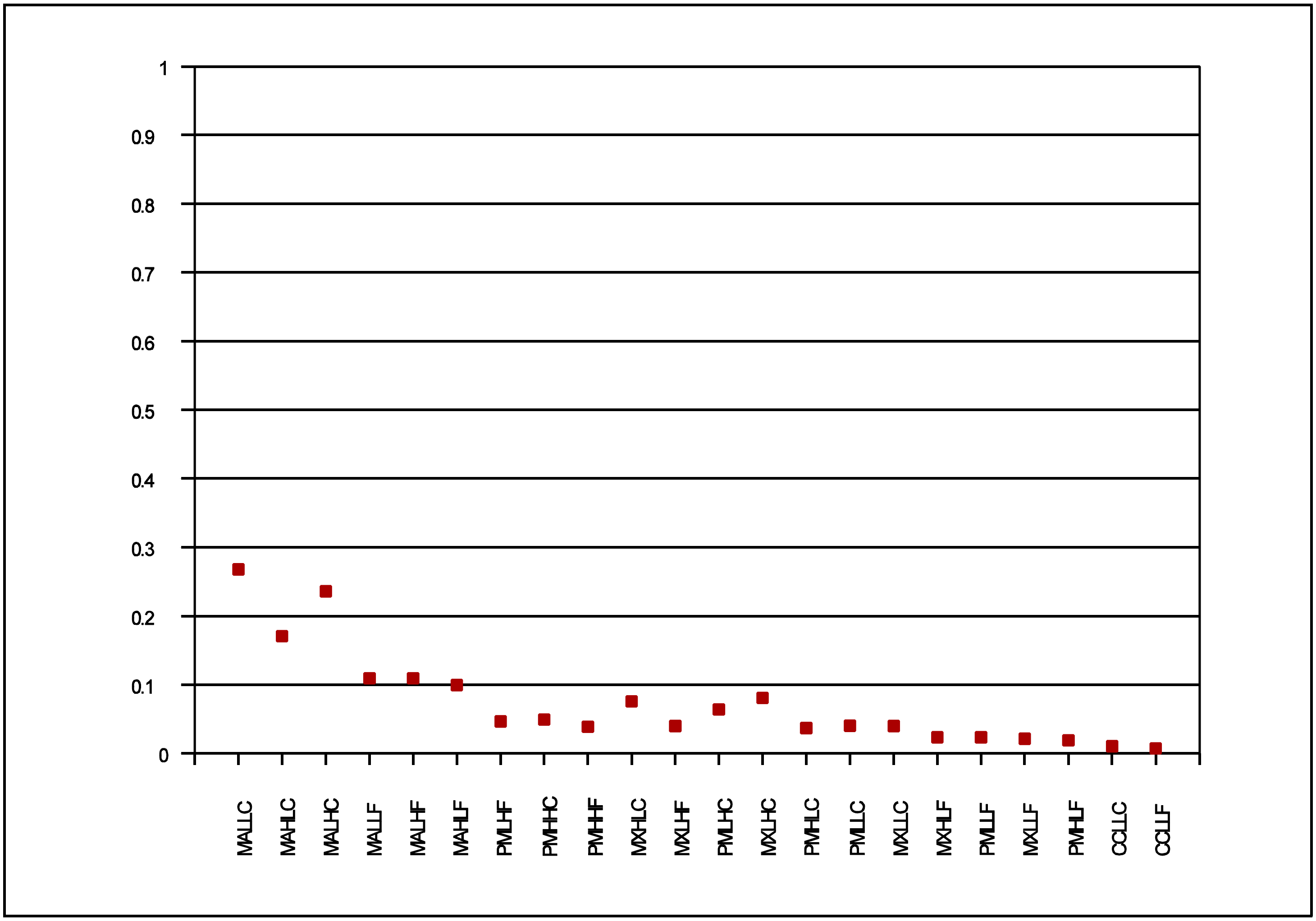

Figure 2-2. CTDMPLUS (24-h HSH)/CTSCREEN (1-h) concentrations for the 22 different source-hill combinations. (See Table A-1 for explanation of abscissa notation.)

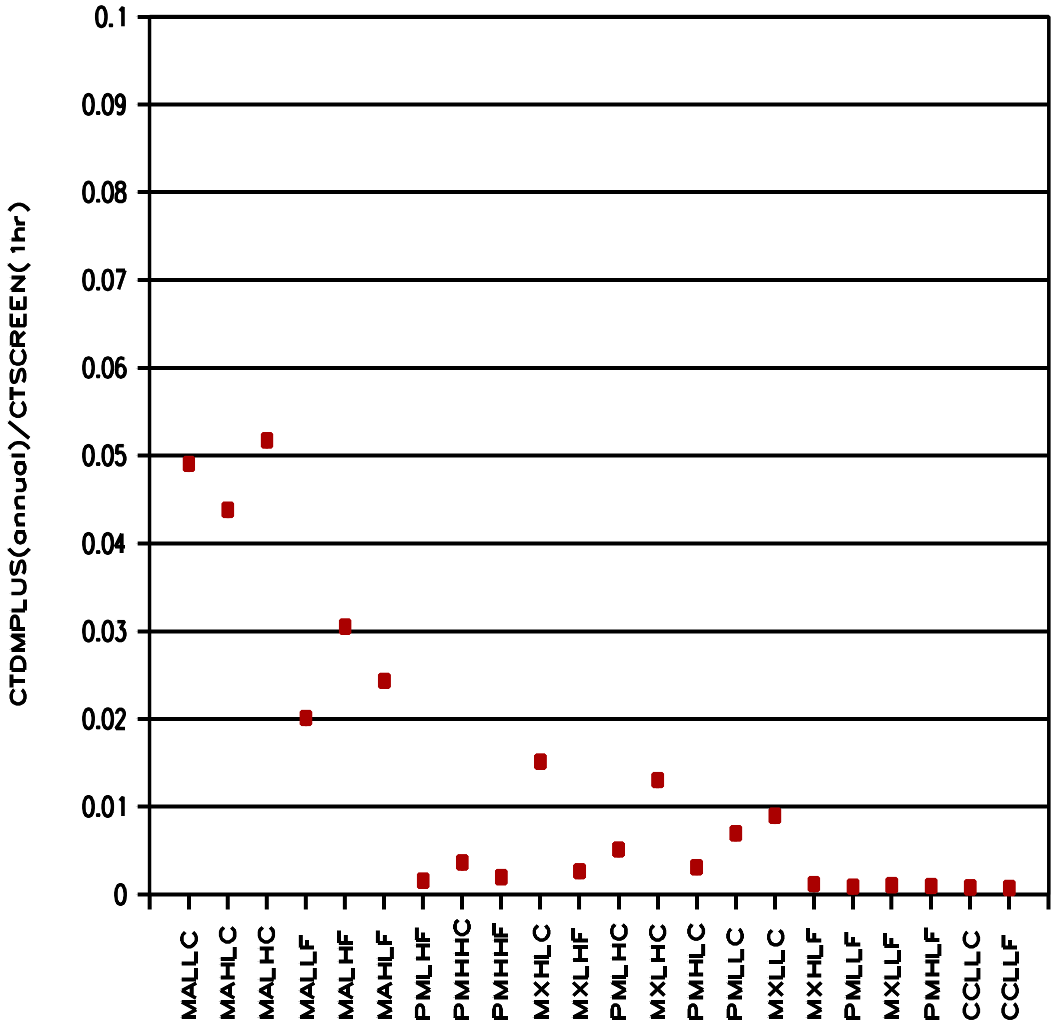

Figure 2-3. CTDMPLUS (Annual)/CTSCREEN (1-h) concentrations for the 22 different source-hill combinations. (See Table A-1 for explanation of abscissa notation.)

SECTION 3

USER INSTRUCTIONS

Contained within CTDMPLUS is a screening mode (CTSCREEN) that, when selected, requires no meteorological input by the user. CTSCREEN uses predetermined matrices of meteorology along with actual source and terrain characteristics to estimate maximum impacts that are of particular interest for planning and regulatory applications. The following subsections briefly describe the input and output files associated with CTSCREEN and give instructions on the use of the program. A complete test case is provided in Appendix B. Users should be familiar with the input requirements of CTDMPLUS (Perry et al. 1989) before attempting to use CTSCREEN. Note that the CTSCREEN mode cannot be selected using the CTDMPLUS menu driver; however, the terrain preprocessor and receptor generator programs can be run from the menu driver. The source code for CTSCREEN is available on the EPA's SCRAM bulletin board.

3.1 INPUT DATA REQUIREMENTS

There are five input files required to run CTSCREEN. Three files are created by the user:

- a file containing program switches, source data, meteorological tower coordinates (see Section 3.1.1), and hill surface roughness lengths (CTDM.IN file);

- a terrain data file which has been created by the terrain preprocessor from user input digitized contour information (TERRAIN file);

- a file containing receptor names, locations, and the associated hill numbers (RECEPTOR file). This file is created by the user either by using a text editor or the RECGEN program.

The other two required files are meteorological files that are provided with CTSCREEN:

- a file containing surface meteorological data (SURFACE file);
- a file containing meteorological profile data (PROFILE file).

These five input files are discussed in more detail in Sections 3.1.1 through 3.1.4. The upper air file, RAWIN, and the variable emissions file, EMISSION, are not used with CTSCREEN.

3.1.1 CTDM.IN File

The input file (CTDM.IN) contains program options, meteorological tower coordinates, source information, and surface roughness lengths for each hill. There are several options in this file that pertain to CTSCREEN only; they are ignored by CTDMPLUS. This allows the user to use a CTDM.IN input file created for use with CTSCREEN with the CTDMPLUS program as well. CTSCREEN can also be set, through the use of model options, to operate in a non-screening mode (i.e., exactly as CTDMPLUS does). A description of the inputs for the CTDM.IN file is given in Table 3-1. CTSCREEN will override the user input for the following switches and set them as indicated below:

Switch name		Value
ICASE	=	0
ITOPN	=	0
ICONC	=	2
ISIGV	=	1
IWD	=	1
ISOR	=	0
IUNSTA	=	0
IEMIS	=	0 (for all sources)

Note that values for these parameters must still be included in the CTDM.IN file to prevent read errors. Sample files are shown in Figures 3-1, 3-2, 3-3, and B-1 (note: Appendix B omitted). Although the meteorological data are provided, the user must include a position (x, y, z) of the meteorological tower base in the CTDM.IN file. The tower should be located in the vicinity of the primary sources. Point-source information in the CTDM.IN file includes stack name, horizontal and vertical coordinates, stack height and diameter at the outlet, stack gas temperature, exit velocity, and emission rate (CTSCREEN does not allow variable emissions). CTSCREEN recognizes primary and secondary sources by the ISCNDRY flag that is included for each source. Sources that have this flag set to "1" are designated as secondary sources. Secondary sources are not used for determining wind directions, but do contribute to the total impact. CTSCREEN does not require stacks to be colocated. However, a common base elevation is calculated (as in CTDMPLUS) to be the minimum of the tower base and the lowest stack base among those input. The lowest "critical elevation" specified in the terrain preprocessor run for each hill must be at or below the common base elevation to avoid a CTSCREEN runtime error.

Surface roughness lengths for the local surface characteristics of each hill are given in the CTDM.IN file. The values of these roughness lengths vary according to vegetative cover and season of the year. See Table 3-2 (Sheih et al. 1979) for guidance.

TABLE 3-1. CONTENTS OF THE CTDM.IN FILE

Line group	Variable name	Columns	Format	Description
1	Title	1-80	A80	80-character header
2	ICASE	*	*	Case study printout option. 0 = No, 1 = Stable hours only, 2 = Unstable hours only, 3 = All hours
	ITOPN	*	*	Create a top 4 table at the end of the run. 0 = NO, 1 = YES
	ICONC	*	*	Concentration output file option. 0 = NO, 1 = BINARY, 2 = TEXT, 3 = TEXT with receptor information
	IMIX	*	*	0 = Use calculated mixing heights as first priority, 1 = Use observed mixing heights as first priority
	IWSI	*	*	Set minimum wind speed = 1.0 m/s. 0 = NO, 1 = YES
	ISIGV	*	*	Assume σ_θ input if 0; σ_v input if 1
	IWD	*	*	Scale wind direction with height. 0 = NO, 1 = YES
	ICHIQ	*	*	0 = output concentrations ($\mu g/m^3$) 1 = output ($\mu s/m^3$)
	ISOR	*	*	Create a source contribution table at the end of run. 0 = NO, 1 = YES
	IUNSTA	*	*	0 = Model only stable hours 1 = Model unstable hours (RAWIN file required) and stable hours
	ISCRN	*	*	0 = Run in regular mode 1 = Run in screening mode, stable hours only 2 = Run in screening mode, unstable hours only 3 = Run in screening mode, stable and unstable hours
	IAUTO	*	*	0 = Do not automate the selection of the wind directions 1 = Model determines the wind directions 2 = Use average wind directions
	IRANGE	*	*	Use a user-specified range of wind directions. 0 = NO, 1 = YES
	IDISCR	*	*	Use user-specified discrete wind directions. 0 = NO, 1 = YES
3	HORIZ	*	*	Horizontal scale factor, converts user units to meters
	VERT	*	*	Vertical scale factor, converts user units to meters
	RLAT	*	*	Site latitude (degrees)
	RLON	*	*	Site longitude (degrees)
	TZONE	*	*	Site time zone (hours behind GMT)
	IPOL	*	*	Pollutant Code (1-4)

(continued)

TABLE 3-1. CONTENTS OF THE CTDM.IN FILE (CONCLUDED)

Line group	Variable name	Columns	Format	Description
4	LABEL	1-20	A20	Meteorological tower name
	XT	21-30	F10.0	X-coordinate of tower (user horizontal units)
	YT	31-40	F10.0	Y-coordinate of tower (user horizontal units)
	ZT	41-50	F10.0	Z-coordinate (user vertical units) of tower base
5**	SNAME	1-15	A15	15 character source name
	ISCN-DRY	16	I1	Secondary source. 0 = NO, 1 = YES
	XS	17-23	F7.0	X-coordinate of source, (user horizontal units)
	YS	24-30	F7.0	Y-coordinate of source (user horizontal units)
	ZS	31-37	F7.0	Source base elevation (user vertical units)
	HS	38-44	F7.0	Stack height (m)
	DS	45-51	F7.0	Stack diameter (m)
	TS†	52-58	F7.0	Stack gas temperature (K)
	VS†	59-65	F7.0	Stack gas exit velocity (m/s)
	QS†	66-72	F7.0	Emission rate (g/s)
	IQ	80	I1	Variable emission rate flag for this stack. 0 = constant, 1 = variable
6	ENDS	1-4	A4	'ENDS'--flag for end of source data
7	ZOH	*	*	Surface roughness length (m) for each hill in the order that the hills appear in the TERRAIN file.
8††	WDLOW	*	*	Lower bound of the wind direction range
	WDUP	*	*	Upper bound of the wind direction range
	WDINC	*	*	Wind direction increment
9‡	NUMWD	*	*	Number of discrete wind directions
	DISCWD	*	*	Values for discrete wind directions (up to 50)

* Free format.
** One line per source; maximum of 40 sources (maximum number can be changed).
† These values are replaced if hourly emissions data are provided for this stack.
†† Included only if IRANGE = 1.
‡ Included only if IDISCR = 1.

```
Piedmont Hill; High-level Low-buoy; Close Source
0 0 2 1 1 1 0 1 0 1 1 1 0 0
1.0, 0.3048,  39.5915, 89.4885, 6, 1
COMPOSITE W-V TOWER       0.0    1000.0    1000.0
High-Low Stack  0   0.0 1000.0 1000.0 150.00   2.00 400.00 10.00 100.00       0
ENDS
0.5
```

Figure 3-1. Sample CTDM.IN file for the following switch settings: iauto = 1, irange = 0, idiscr = 0.

```
Piedmont Hill; High-level Low-buoy; Close Source
0 0 2 1 1 1 0 1 0 1 1 0 1 0
1.0, 0.3048,  39.5915, 89.4885, 6, 1
COMPOSITE W-V TOWER       0.0    1000.0    1000.0
High-Low Stack  0   0.0 1000.0 1000.0 150.00   2.00 400.00 10.00 100.00       0
ENDS
0.5
330  360  5
```

Figure 3-2. Sample CTDM.IN file for the following switch settings: iauto = 0, irange = 1, idiscr = 0.

```
Piedmont Hill; High-level Low-buoy; Close Source
0 0 2 1 1 1 0 1 0 1 1 0 0 1
1.0, 0.3048,  39.5915, 89.4885, 6, 1
COMPOSITE W-V TOWER       0.0    1000.0    1000.0
High-Low Stack  0   0.0 1000.0 1000.0 150.00   2.00 400.00 10.00 100.00       0
ENDS
0.5
5  330  335  340  345  350
```

Figure 3-3. Sample CTDM.IN file for the following switch settings: iauto = 0, irange = 0, idiscr = 1.

TABLE 3-2. TYPICAL SURFACE ROUGHNESS LENGTHS (METERS) FOR LAND USE TYPES AND SEASONS

Land use type	Season* Spring	Summer	Autumn	Winter
1. Water (fresh water and sea water)	0.0001	0.0001	0.0001	0.0001
2. Deciduous forest	1.00	1.30	0.80	0.50
3. Coniferous forest	1.30	1.30	1.30	1.30
4. Swamp	0.20	0.20	0.20	0.05
5. Cultivated land	0.03	0.20	0.05	0.01
6. Grassland	0.05	0.10	0.01	0.001
7. Urban	1.00	1.00	1.00	1.00
8. Desert shrubland	0.30	0.30	0.30	0.15

*Definitions of seasons:

Spring refers to periods when vegetation is emerging or partially green. This is a transitional situation that applies for 1-2 months after the last killing frost in spring.

Summer applies to the period when vegetation is lush and healthy, typical of midsummer, but also of other seasons in locations where frost is less common.

Autumn refers to a period when freezing conditions are common, deciduous trees are leafless, crops are not yet planted or are already harvested (bare soil exposed), grass surfaces are brown, and no snow is present.

Winter conditions apply for snow-covered surfaces and subfreezing temperatures.

The wind direction used by CTSCREEN may be determined in a number of ways, the selection of which is controlled via switches in the CTDM.IN file (see Table 3-1 for further descriptions of these switches). The methods for determining the wind direction are described below:

(1) the model automatically determines a set of wind directions based on the source-hill geometry, if the user selects a value of "1" for the iauto switch;

(2) in addition to the individual wind directions (method 1), the model determines the average of the directions from the sources to a particular hill, if the iauto switch is set equal to "2";

(3) a range of wind directions and an increment can be specified by the user, by selecting a value of "1" for the irange switch;

(4) up to 50 discrete wind directions can be specified by the user, by selecting a value of "1" for the idiscr switch; or

(5) any combination of the above.

If the user selects method 3, the upper and lower limits of the wind speed range and the increment are included in the CTDM.IN file. If the user selects method 4, then the discrete wind directions are specified in the CTDM.IN file.

3.1.2 TERRAIN File

The terrain data file is created by the terrain preprocessor (see Mills et al. 1987) and is used by CTSCREEN without modification. The format of this file is given in Table 3-3; an example is shown in Figure B-2 (note: Appendix B omitted).

3.1.3 RECEPTOR File

The RECEPTOR file contains receptor names, coordinates, and hill number. This file can be used directly from the output of the receptor generator, RECGEN (see Section 4.1 in Perry et al. 1989) or can be created using a text editor. The format of this file is shown in Table 3-4; an example is shown in Figure B-3 (note: Appendix B omitted).

3.1.4 SURFACE and PROFILE Files

The SURFACE and PROFILE files are provided with CTSCREEN (CTSCREEN.SFC and CTSCREEN.PFL, respectively) and are used without modification. These files are constructed so that the matrices of meteorology described in Section 2.1 are used to run the model. The SURFACE file is shown in Figure B-4 (note: Appendix B omitted). The PROFILE file is shown in Figure B-5 (note: Appendix B omitted).

TABLE 3-3. FORMAT OF THE TERRAIN INPUT DATA FILE
(FROM THE TERRAIN PREPROCESSOR)

Record group	Parameter name	Columns	Format	Description
1*	NH†	6-7	I2	Hill identification number
	NZ††	9-10	I2	Number of critical elevations
	HTP	21-30	E10.4	Hill-top elevation (user units)
	HNAME	31-45	A15	Hill name
2**	ZH	1-10	F10.3	Critical elevations (user units)
	XHW,YHW	11-30	2F10.3	x,y-coordinates of the ellipse centroid for the critical elevation
	MAJORW	31-40	F10.3	Orientation (degrees) of the ellipse major axis with respect to north
	MAJAXW MINAXW	41-60	2F10.3	Semi-major and semi-minor axes lengths for the ellipse at the critical elevation
3**	ZH	1-10	F10.3	Critical elevation (must match critical elevations in Record Group 2)
	L	10-30	2E10.4	x,y-coordinates for the fitted cutoff hill centroid
	MAJORL	31-40	F10.3	Orientation of the fitted cut off hill major axis with respect to north (degrees)
	EXPOMA EXPOMI	41-60	2F10.3	Inverse polynominal exponent parameters for the major and minor fitted hill axes
	SCALMA SCALMI	61-80	2F10.3	Inverse polynominal length scale parameters for the major and minor fitted hill axes

* Record groups 1-3 are repeated for each hill.
** NZ records for group 2 are followed by NZ records for group 3.
† Maximum of 25 hills.
†† Maximum of 21 hill contours.

TABLE 3-4. FORMAT OF THE RECEPTOR INPUT DATA FILE*

Record group	Variable name	Columns	Format	Description
1**	RNAME	1-16	A16	16-character receptor name
	XR	2 1-30	F10.0	x-coordinate of receptor (user horizontal units)
	YR	31-40	F10.0	y-coordinate of receptor (user horizontal units)
	ZR	41-50	F10.0	Height of receptor above local ground surface (user vertical units)
	GE	51-60	F10.0	Ground-level elevation (user vertical units)
	NH***	61-65	I5	Hill number of this receptor

* No special line is required to signify the end of receptor input; this is signified by the end of the file.

** One line per receptor; maximum of 400 receptors.

*** Hill number 0 is used to indicate flat terrain algorithm to be used for this receptor.

3.2 CTSCREEN OUTPUT FILES

3.2.1 CTDM.OUT File

CTSCREEN creates an output listing which contains a verification of input data from the CTDM.IN file, a line printer map showing the relative locations of sources and receptors, and the information contained in the TERRAIN file. Note that the ICASE switch is set to "0" by CTSCREEN so that a case-study output listing cannot be created. A sample file is shown in Figure B-6 (note: Appendix B omitted).

3.2.2 STCONC and UNCONC Files

CTSCREEN creates two text files of concentrations: one for the simulations of stable (Monin-Obukhov length, $L > 0$) conditions (STCONC), and one for the simulations of unstable/convective ($L < 0$) conditions (UNCONC). Each file indicates the meteorology associated with all of the individual simulations and the concentration at each receptor for each simulation. The format of these files is given in Table 3-5 (both files have the same format). Sample STCONC and UNCONC files are shown in Figures B-7 and B-8 (note: Appendix B omitted), respectively.

3.2.3 SUMRE File

The SUMRE file lists the maximum concentration predicted for stable/neutral conditions and the maximum predicted concentration for unstable/convective conditions as well as the meteorology that produced these concentrations. It gives the maximum overall value calculated for the 3-h and 24-h HSH and annual high estimates for regulatory purposes. It also shows the maximum predicted concentration for each receptor and the meteorology that produced that concentration. A sample file is shown in Figure B-9 (omitted).

TABLE 3-5. FORMAT OF THE STCONC AND UNCONC FILES

Line group	Columns	Format	Description
1 *	1-20	A20	Concentration units for this model run
	25-28	I4	Number of receptors
2 **	2-5	I4	Simulation number
	8-11	I4	Number of receptor with maximum concentration
3	2-6	F5.1	Wind direction used for this simulation
	10-14	F5.1	Wind speed used for this simulation
	18-24	F7.2	σ_v used for this simulation
	28-34	F7.2	σ_w used for this simulation
	38-41	F6.3	Potential temperature gradient used for this simulation
	45-50	F6.1	Mixing height used for this simulation
	54-58	F5.1	u_* used for this simulation
	62-66	F5.1	Monin-Obukhov length used for this simulation
4 †	1-80	8F10.3	Concentrations at each receptor

* Appears only once, at the beginning of the file.

** Each hour.

† Eight values per line until receptor list is exhausted, each hour.

3.3 INSTRUCTIONS FOR EXECUTION OF CTSCREEN

The size of the CTSCREEN executable file is approximately 550K bytes. It is distributed in an archived format and must be de-archived using the CRE8CTSC program. The CRE8CTSC program will extract the CTSCREEN.EXE, CTSCREEN.SFC, CTSCREEN.PFL, and RUNCTSC.BAT from their packed format and put them in the current directory. In order to run CTSCREEN, the following steps should be completed (the file naming convention from CTDMPLUS has been retained; see Table 5-2 in Perry et al. 1989):

- Using a text editor, create the *.CIN file.

- Using the terrain preprocessor programs, create the *.HCO file. (The terrain preprocessor programs can be run using the menu driver.)

- Using RECGEN or a text editor, create the *.RCT file. (RECGEN can be run using the menu driver.)

- At the DOS prompt, type RUNCTSC %1, where %1 is the name of the case to be run. The batch file will then copy %1.CIN to CTDM.IN, %1.HCO to TERRAIN, %1.RCT to RECEPTOR, CTSCREEN.SFC to SURFACE, CTSCREEN.PFL to PROFILE, and execute CTSCREEN. After the CTSCREEN run has completed, the batch file will copy STCONC to %1.STC, UNCONC to %1.UNC, and SUMRE to %1.SUM and delete the temporary files that it created. Note that the batch file assumes that all of the files are in the same directory as the batch file. The batch file can be customized for your system using a text editor.

3.4 CTSCREEN SUBROUTINE STRUCTURE

The subroutine structure of CTSCREEN is slightly different than that of CTDMPLUS. The main program, CTSCREEN, calls several subroutines which read in much of the input data for a run. It then calls SEQSCR which primarily determines the wind direction used for a particular simulation. SEQSCR calls CONCALC which determines whether a particular simulation is modeled as stable/neutral or unstable/convective. NITCALC and DAYSCR perform the calculations of the concentrations for stable/neutral and unstable/convective conditions respectively. Figures 3-4 through 3-8 from the original document have been omitted.

Figure 3-4. Outline of the main program, CTSCREEN.

Figure 3-5. Outline of the subroutine, SEQSCR.

Figure 3-5. (continued...)

Figure 3-5. (concluded)

Figure 3-6. Outline of the subroutine, CONCALC.

Figure 3-7. Outline of the subroutine, NITCALC.

Figure 3-8. Outline of the subroutine, DAYSCR.

SECTION 4

REFERENCES

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APPENDIX A

COMPARISONS BETWEEN CTSCREEN AND OTHER REGULATORY MODELS

In order to evaluate the usefulness of CTSCREEN as a screening tool, predicted concentrations from CTSCREEN were compared with those from a refined model, CTDMPLUS, and two established regulatory screening models, COMPLEX-I and VALLEY. These models were run for 22 different plume impaction scenarios. The meteorology, terrain features, receptor locations, and source characteristics used to run the models are described in Section A.1. The results of the testing are discussed in Section A.2. A detailed description of the 22 scenarios is found in Brode (1989).

A.1 DESIGN OF THE STUDY

A.1.1 Models Used in the Comparison

The two models selected for comparison with CTSCREEN were COMPLEX-I and VALLEY. These models were run, in screening mode, according to the recommendations found in the "Guideline on Air Quality Models (Revised)" [EPA 1986].

A.1.2 Meteorology Used in the Comparison

The Westvaco 1981 meteorological database (Wackter and Londergan, 1984) was used for running CTDMPLUS and COMPLEX-I. VALLEY does not require a meteorological input file. The matrix of meteorology described in Section 2.1 was used for running CTSCREEN.

A.1.3 Terrain Features and Receptor Locations

Four terrain shapes were used in the study:

(1) Piedmont Hill - A complex, three-dimensional hill with a height above stack base of 378 meters;
(2) Montour Ridge (Crosswind) - A two-dimensional hill, oriented with the major axis perpendicular to the flow, extending 222 meters above stack base;
(3) Montour Ridge (Alongwind) - A two-dimensional hill, oriented with the major axis parallel to the flow, extending 222 meters above stack base; and
(4) Cinder Cone Butte - A simple, almost axisymmetric 100-meter high hill.

Receptors were placed on the hill contours as shown in Figures A-1 through A-3. Receptor locations for VALLEY were generated by translating the receptor file and terrain information for CTDMPLUS into the format required by VALLEY.

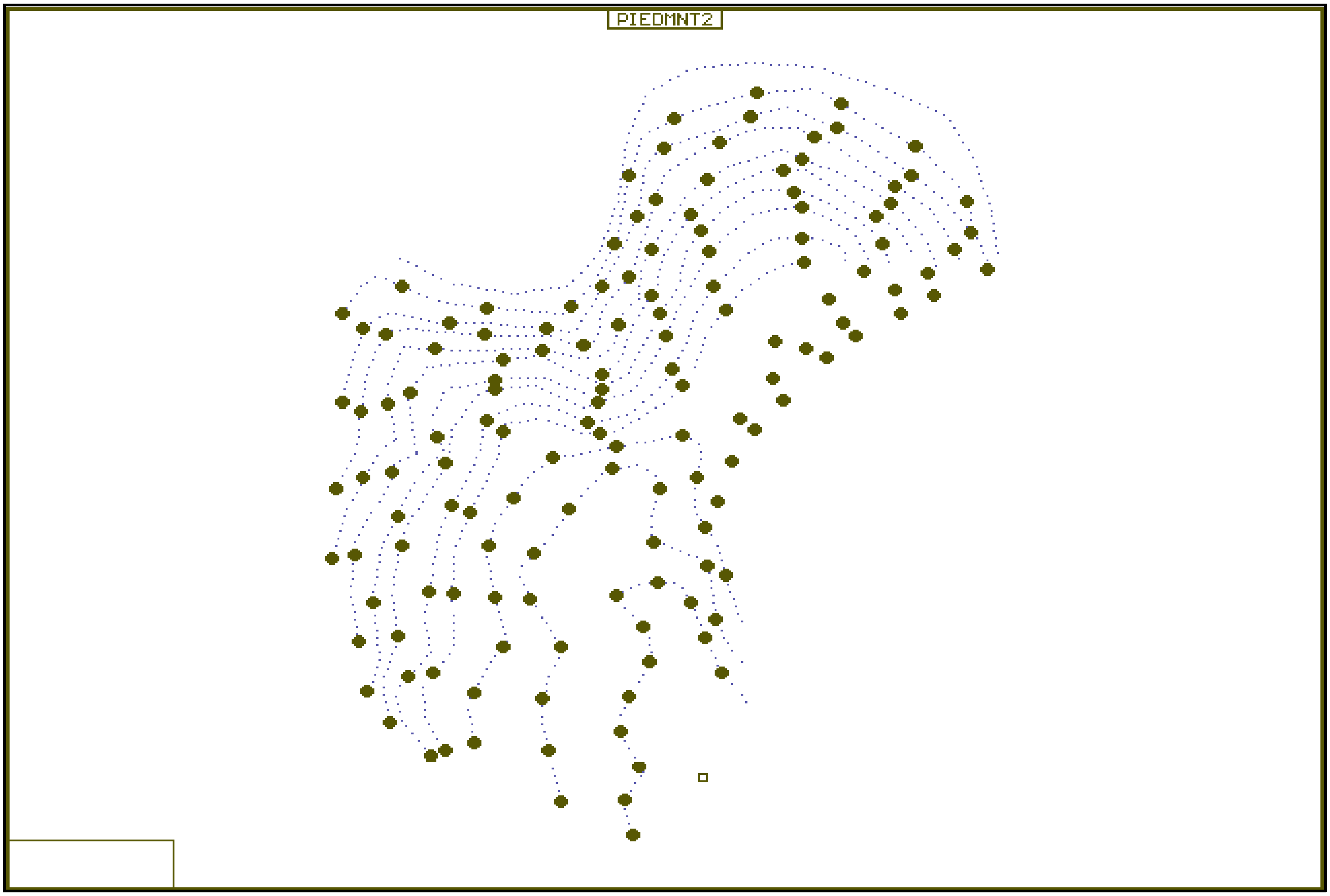
A.1.4 Source Characteristics

A variety of sources were modeled with the four terrain features. Variations in buoyancy flux, stack height, and distance from source to hill center were included. The characteristics of these sources are given in Table A-1.

A.2 RESULTS AND DISCUSSION

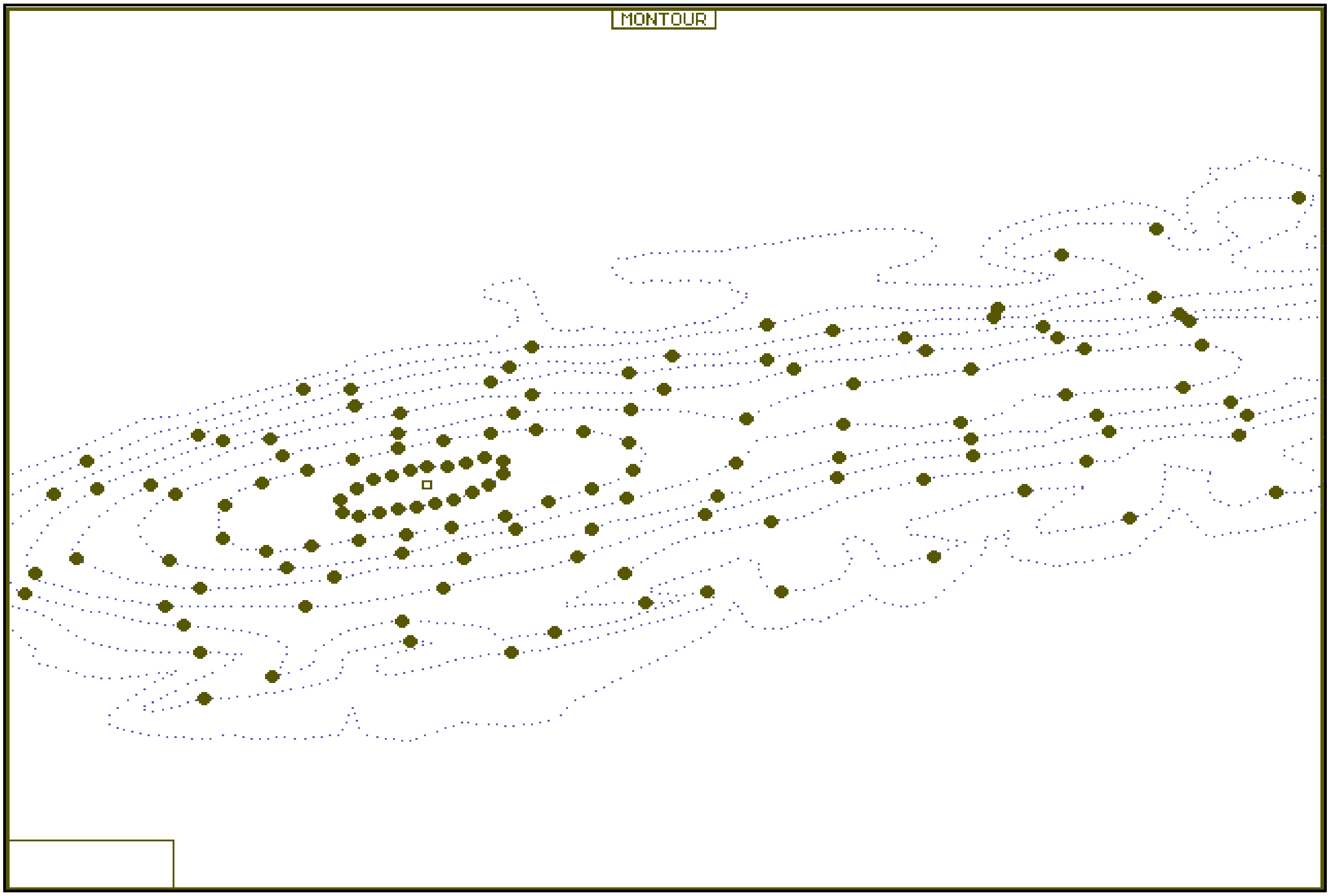
In order for a screening model to be useful, it should consistently predict concentrations that are more conservative than (yet comparable to) refined models which require on-site meteorology. In this study, CTSCREEN is compared with CTDMPLUS (which requires substantial on-site information) and with two existing regulatory screening techniques.

Table A-2 shows the results from the four models for all 22 scenarios for averaging times of 1, 3, and 24 hours, and annual estimates. Table A-3 gives the same results, but the concentrations have been normalized by the corresponding values for CTDMPLUS. Figures A-4, A-5, and A-6 show the comparison of CTSCREEN normalized estimates with those from COMPLEX-I and VALLEY. In 77% of the cases, CTSCREEN predicts 3-h HSH concentrations that are lower than those of COMPLEX-I, but still conservative with respect to CTDMPLUS (Figure A-4). For the 24-h averaging time, CTSCREEN provided estimates lower than those of COMPLEX-I in 45% of the cases and lower than VALLEY for about 73% of the cases, but conservative with respect to CTDMPLUS (Figure A-5).



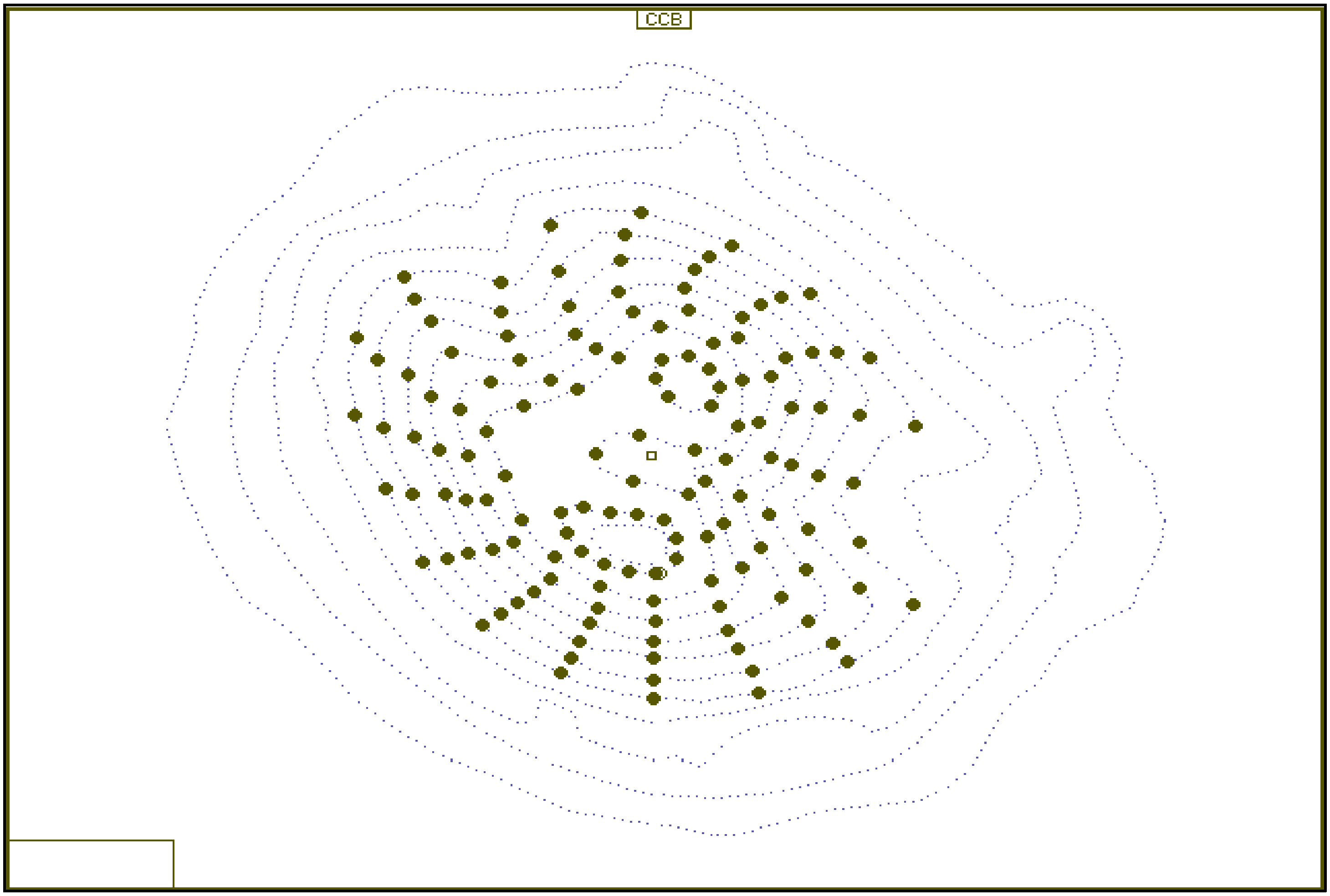
Receptors are circles located along the dotted contour lines.
Hill height is 378 meters above stack base.
Sources are located north of the hill.

Figure A-1. Receptor locations for Piedmont Hill.



Receptors are circles located along the dotted contour lines.
Hill height is 222 meters above stack base.
Sources are located to the north and west of the hill.

Figure A-2. Receptor locations for Montour Ridge.



Receptors are circles located along the dotted contour lines.
Hill height is 100 meters above stack base.
Sources are located to the north of the hill.

Figure A-3. Receptor locations for Cinder Cone Butte.

TABLE A-1. CHARACTERISTICS OF THE SOURCE-HILL COMBINATIONS USED IN THE COMPARISONS

Hill name	Source abbrev.[d]	Stack height	Stack diameter	Exit velocity	Exit temp.	Buoyancy flux	Source-hill center distance
		m	m	m/s	K	m^4/s^3	m
Piedmont [a]	PMLLC	30	2	10	400	26	2,730
Piedmont	PMLLF	30	2	10	400	26	11,696
Piedmont	PMLHC	30	6	30	500	1,096	2,730
Piedmont	PMLHF	30	6	30	500	1,096	11,696
Piedmont	PMHLC	150	2	10	400	26	2,730
Piedmont	PMHLF	150	2	10	400	26	11,696
Piedmont	PMHHC	150	6	30	500	1,096	2,730
Piedmont	PMHHF	150	6	30	500	1,096	11,696
Montour-X [b]	MXLLC	30	2	10	400	26	2,000
Montour-X	MXLLF	30	2	10	400	26	11,000
Montour-X	MXLHC	30	6	30	500	1,096	2,000
Montour-X	MXLHF	30	6	30	500	1,096	11,000
Montour-X	MXHLC	150	2	10	400	26	2,000
Montour-X	MXHLF	150	2	10	400	26	11,000
Montour-A [b]	MALLC	30	2	10	400	26	3,500
Montour-A	MALLF	30	2	10	400	26	12,500
Montour-A	MALHC	30	6	30	500	1,096	3,500
Montour-A	MALHF	30	6	30	500	1,096	12,500
Montour-A	MAHLC	150	2	10	400	26	3,500
Montour-A	MAHLF	150	2	10	400	26	12,500
Cinder Cone [c]	CCLLC	30	2	10	400	26	1,500
Cinder Cone	CCLLF	30	2	10	400	26	10,500

a. See Figure A-1.
b. See Figure A-2.
c. See Figure A-3.
d. The source abbreviation represents--
- (1,2) Hill name:
  - PM = Piedmont Hill,
  - MX = Montour Ridge (crosswind),
  - MA = Montour Ridge (alongwind),
  - CC = Cinder Cone Butte
- (3) Stack height:
  - L = Low (30 m)
  - H = High (150 m)
- (4) Buoyancy flux:
  - L = Low (26 m^4/s^3)
  - H = High (1,096 m^4/s^3)
- (5) Source-hill center distance:
  - C = Close (< 4,000 m)
  - F = Far (> 4,000 m)

TABLE A-2. COMPARISON OF MAXIMUM 1-h, 3-h, 24-h, AND ANNUAL ESTIMATES FROM CTSCREEN, CTDMPLUS, COMPLEX-I, AND VALLEY

	CTSCREEN 1-h	CTSCREEN 3-h	CTSCREEN 24-h	CTSCREEN Annual	CTDMPLUS 1-h	CTDMPLUS 3-h HSH	CTDMPLUS 24-h HSH	CTDMPLUS Annual	CPLXI 1-h HSH	CPLXI 3-h HSH	CPLXI 24-h HSH	CPLXI Annual	VALLEY 1-h	VALLEY 24-h
PMHHC	4.65	3.26	0.70	0.14	4.30	1.55	0.23	0.017	8.35	5.98	1.14	0.06	6.84	1.71
PMHHF	1.03	0.72	0.15	0.03	1.03	0.31	0.04	0.002	1.33	0.58	0.11	0.01	1.01	0.25
PMHLC	26.81	8.76	4.02	0.80	16.00	5.23	1.00	0.083	53.66	32.50	6.79	0.49	28.60	7.15
PMHLF	3.18	2.23	0.48	0.10	1.16	0.38	0.06	0.003	2.44	1.08	0.19	0.01	5.68	1.42
PMLHC	8.62	6.03	1.29	0.26	5.11	2.48	0.55	0.044	18.65	17.04	3.89	0.23	12.24	3.06
PMLHF	1.28	0.90	0.19	0.04	1.06	0.51	0.06	0.002	2.31	1.37	0.25	0.01	1.14	0.29
PMLLC	39.27	27.49	5.89	1.18	18.70	6.27	1.59	0.273	86.93	75.97	22.78	2.71	34.28	8.57
PMLLF	3.36	2.35	0.50	0.10	1.16	0.44	0.08	0.003	4.12	2.42	0.46	0.01	9.92	2.48
MXHLC	12.44	8.71	1.87	0.37	5.58	3.65	0.94	0.188	22.68	12.15	2.92	0.20	15.80	3.95
MXHLF	1.69	1.18	0.25	0.05	0.90	0.23	0.04	0.002	2.16	0.90	0.21	0.01	5.48	1.37
MXLHC	7.07	4.95	1.06	0.21	3.05	1.99	0.57	0.092	9.35	6.15	1.25	0.11	7.52	1.88
MXLHF	0.75	0.53	0.11	0.02	0.50	0.22	0.03	0.002	1.53	0.98	0.19	0.01	1.04	0.26
MXLLC	25.57	17.90	3.84	0.77	11.10	3.71	1.02	0.230	50.75	45.60	9.65	1.15	24.24	6.06
MXLLF	3.70	2.59	0.56	0.11	1.08	0.47	0.08	0.004	3.73	3.28	0.77	0.02	9.96	2.49
MAHLC	5.80	4.06	0.87	0.17	12.80	4.81	0.99	0.254	16.29	10.91	3.42	0.64	14.52	3.63
MAHLF	1.81	1.27	0.27	0.05	2.08	0.77	0.18	0.044	2.64	1.74	0.46	0.10	5.24	1.31
MALHC	2.88	2.02	0.43	0.09	5.12	1.96	0.68	0.149	5.69	5.66	2.10	0.36	4.84	1.21
MALHF	0.82	0.57	0.12	0.02	0.73	0.42	0.09	0.025	1.39	1.38	0.43	0.08	0.91	0.23
MALLC	27.90	19.53	4.19	0.84	35.10	27.13	7.47	1.369	43.49	41.65	15.88	2.43	21.28	5.32
MALLF	4.48	3.14	0.67	0.13	5.25	2.76	0.49	0.090	3.68	3.66	1.16	0.23	9.92	2.48
CCLLC	27.11	18.98	4.07	0.81	4.88	1.93	0.29	0.021	46.67	28.31	5.46	0.08	24.12	6.03
CCLLF	4.08	2.86	0.61	0.12	0.48	0.16	0.03	0.003	3.64	2.05	0.39	0.01	9.80	2.45

TABLE A-3. COMPARISON OF NORMALIZED (BY CTDMPLUS) MAXIMUM 1-h,3-h, 24-h
AND ANNUAL ESTIMATES FROM CTSCREEN, COMPLEX-I, AND VALLEY

		CTSCREEN 1-h	CTSCREEEN 3-h	CTSCREEN 24-h	CTSCREEN Annual	CPLXI 1-h HSH	CPLXI 3-h HSH	CPLXI 24-h HSH	CPLXI Annual	VALLEY 1-h	VALLEY 24-h
Piedmont:	PMHHC	1.08	2.10	3.03	8.21	1.94	3.86	4.96	3.53	1.59	7.43
	PMHHF	1.00	2.33	3.86	15.45	1.29	1.87	2.75	5.00	0.98	6.31
	PMHLC	1.68	3.59	4.02	9.69	3.35	6.21	6.79	5.90	1.79	7.15
	PMHLF	2.74	5.86	7.95	31.80	2.10	2.84	3.17	3.33	4.90	23.67
	PMLHC	1.69	2.43	2.35	5.88	3.65	6.87	7.07	5.23	2.40	5.56
	PMLHF	1.21	1.76	3.20	19.20	2.18	2.69	4.17	5.00	1.08	4.75
	PMLLC	2.10	4.38	3.70	4.32	4.65	12.12	14.33	9.93	1.83	5.39
	PMLLF	2.90	5.35	6.30	33.60	3.55	5.50	5.75	3.33	8.55	31.00
Montour-X:	MXHLC	2.23	2.39	1.99	1.99	4.06	3.33	3.11	1.06	2.83	4.20
	MXHLF	1.88	5.14	6.34	25.35	2.40	3.91	5.25	5.00	6.09	34.25
	MXLHC	2.32	2.49	1.86	2.31	3.07	3.09	2.19	1.20	2.47	3.30
	MXLHF	1.50	2.39	3.75	11.25	3.06	4.45	6.33	5.00	2.08	8.67
	MXLLC	2.30	4.82	3.76	3.34	4.57	12.29	9.46	5.00	2.18	5.94
	MXLLF	3.43	5.51	6.94	27.7	53.45	6.98	9.63	5.00	9.22	31.13
Montour-A:	MAHLC	0.45	0.84	0.88	0.69	1.27	2.27	3.45	2.52	1.13	3.67
	MAHLF	0.87	1.65	1.51	1.23	1.27	2.26	2.56	2.27	2.52	7.28
	MALHC	0.56	1.03	0.64	0.58	1.11	2.89	3.09	2.42	0.95	1.78
	MALHF	1.12	1.37	1.37	0.98	1.90	3.29	4.78	3.20	1.25	2.53
	MALLC	0.79	0.72	0.56	0.61	1.24	1.54	2.13	1.78	0.61	0.71
	MALLF	0.85	1.14	1.37	1.49	0.70	1.33	2.37	2.56	1.89	5.06
CC-Butte:	CCLLC	5.56	9.83	14.02	38.73	9.56	14.67	18.83	3.81	4.94	20.79
	CCLLF	8.50	17.85	20.40	40.80	7.58	12.81	13.00	3.33	20.42	81.67

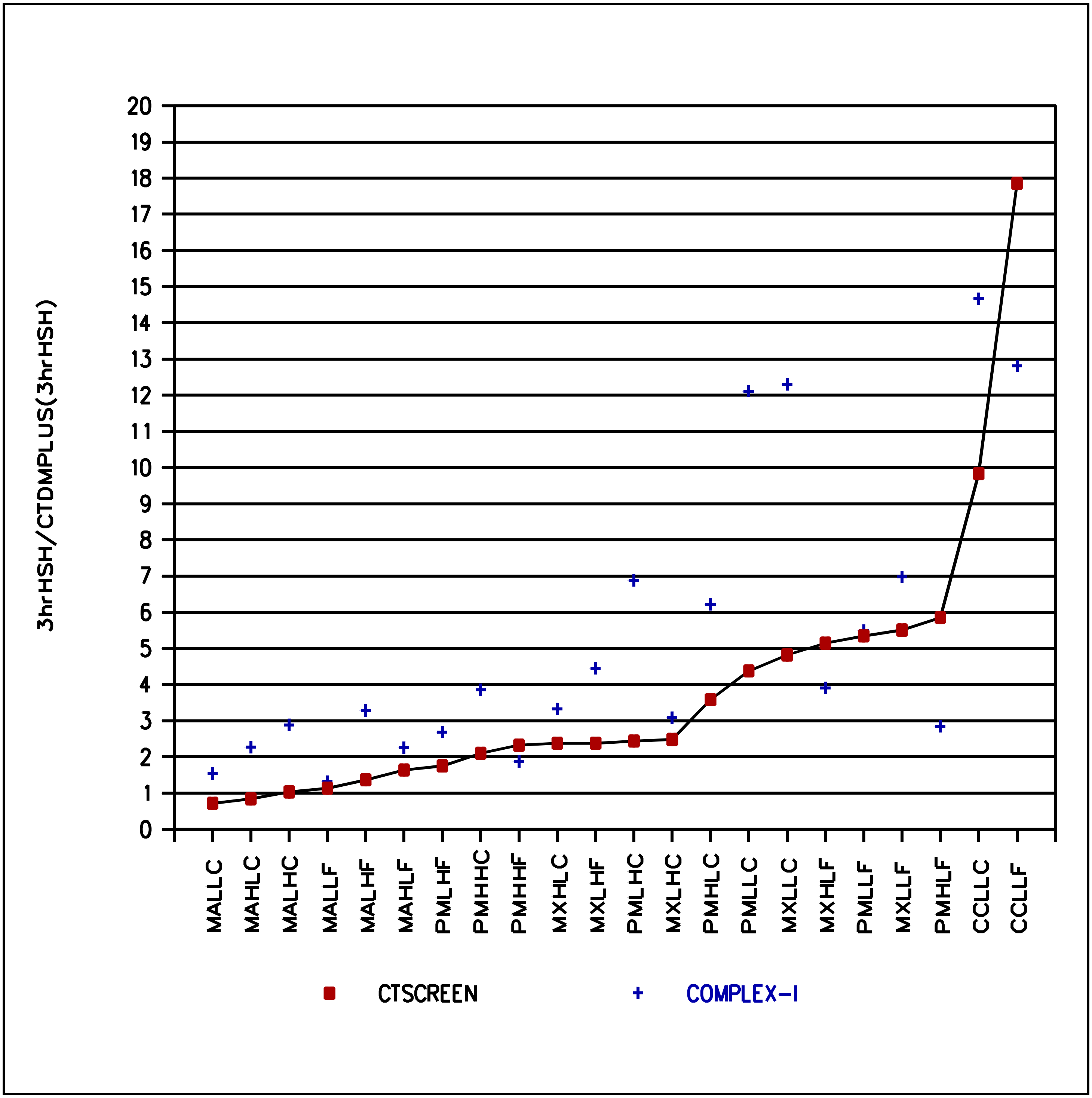


Figure A-4. Comparison of CTSCREEN with COMPLEX-I for the 3-h averaging time. Concentration values are normalized by CTDMPLUS predictions. (See Table A-1 for explanation of abscissa notation.)

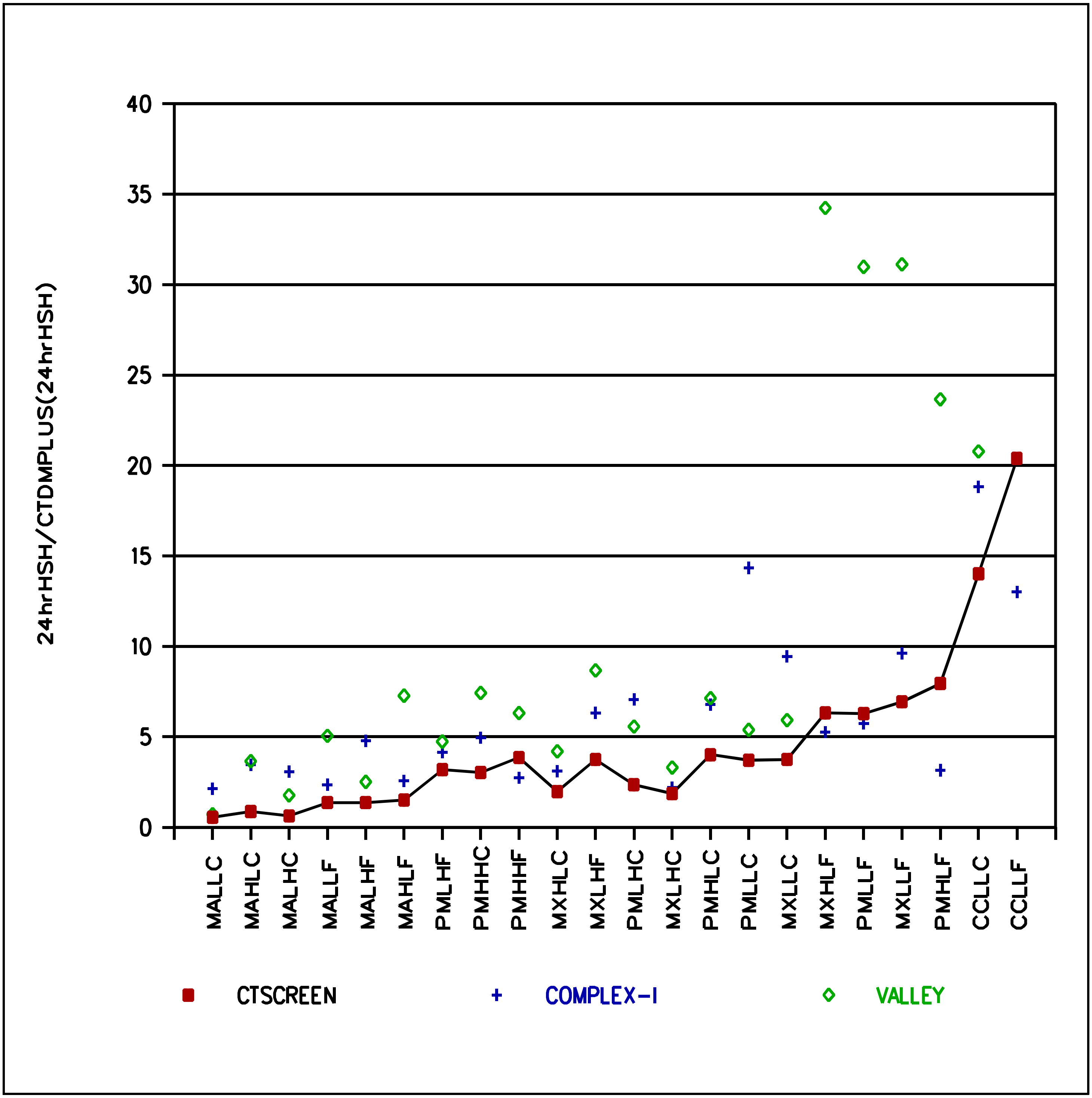


Figure A-5. Comparison of CTSCREEN with COMPLEX-I and VALLEY for the 24-h averaging time. Concentration values are normalized by CTDMPLUS predictions. Note that the estimate provided by VALLEY for the CCLLF source is off the scale (81.67). (See Table A-1 for explanation of abscissa notation.)

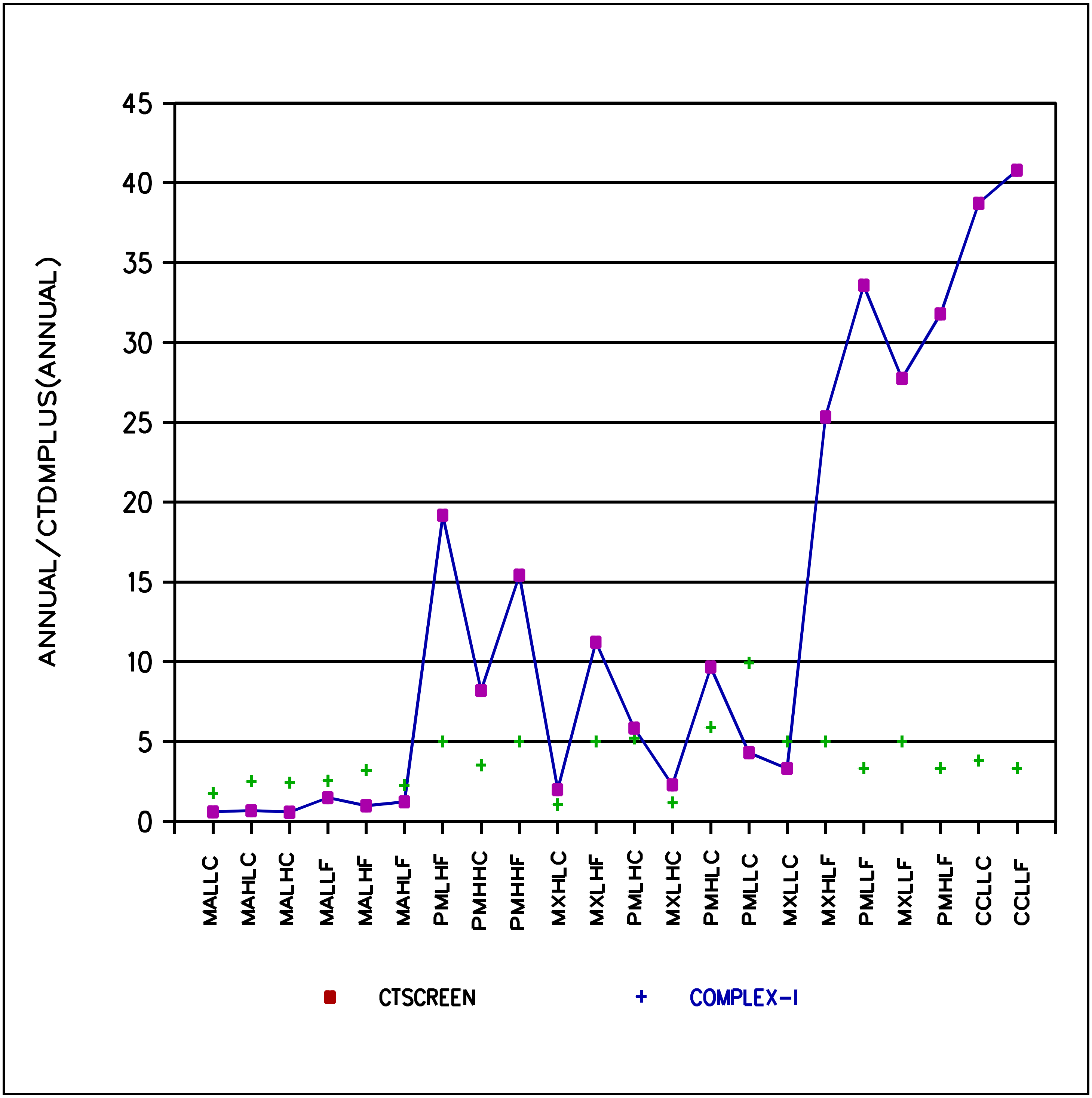


Figure A-6. Comparison of CTSCREEN with COMPLEX-I for the annual averaging time. Concentration values are normalized by CTDMPLUS predictions. (See Table A-1 for explanation of abscissa notation.)

APPENDIX B

TEST CASE FILES

(<u>NOTE</u>: For access to these files, please look in the "FILE TRANSFERS" area of the SCRAM BBS under "<A>ir Quality Models"; then go to "SCREENING PROCEDURES" and find "CTSCREEN"...)