POINT SOURCE MODEL
EVALUATION AND DEVELOPMENT
STUDY

Appendix C - User Guide to IMPACT

prepared by

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California Air Resources Board
and the
California Energy Resources Conservation
and Development Commission

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USER GUIDE TO IMPACT

INTEGRATED MODEL FOR PLUMES AND ATMOSPHERICS IN COMPLEX TERRAIN

APPENDIX C

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1. INTRODUCTION

The Integrated Model for Plumes and Atmospherics in Complex Terrain (IMPACT) is the computer code for a three-dimensional grid model for calculating the impact of pollutants, either inert or reactive, in simple or complex terrain, emitted from either point or area sources. As such, it is one of the most comprehensive air pollution model yet developed. It automatically treats single or multiple point or area sources, the effects of arbitrary vertical temperature stratifications (multiple inversions) on the wind and diffusion fields, shear flows caused by the atmospheric boundary layer or by terrain effects, and chemical transformations (such as those creating photochemical smog).

The code was written in modular format such that the incorporation of new or alternative formulations for plume rise, winds diffusion, advection, and chemistry is particularly straightforward with minimal changes required in the existing program. A macro-flow diagram of IMPACT is shown in Figure 1. The shaded boxes represent the five modules that are the major components of IMPACT; the rest of the code is concerned with program control and input and output functions.

The next section of this user guide contains a description of the various components of the IMPACT code. These descriptions may contain flow diagrams, input/output variables, equations and graphs as required to describe the routines. Section 3 presents a discussion of the various options available in the code, including selection of chemistries, diffusion models, averaging duration, and output plots and edits. Also included in this section is a discussion of the limitations on problem size, data input, etc. A detailed discussion of the input data and source file structure for IMPACT is presented in section 4. Also included is a discussion on how to modify the common storage block for different size problems. Section 5 provides helpful caveats for IMPACT usuage. A sample run concludes the document.

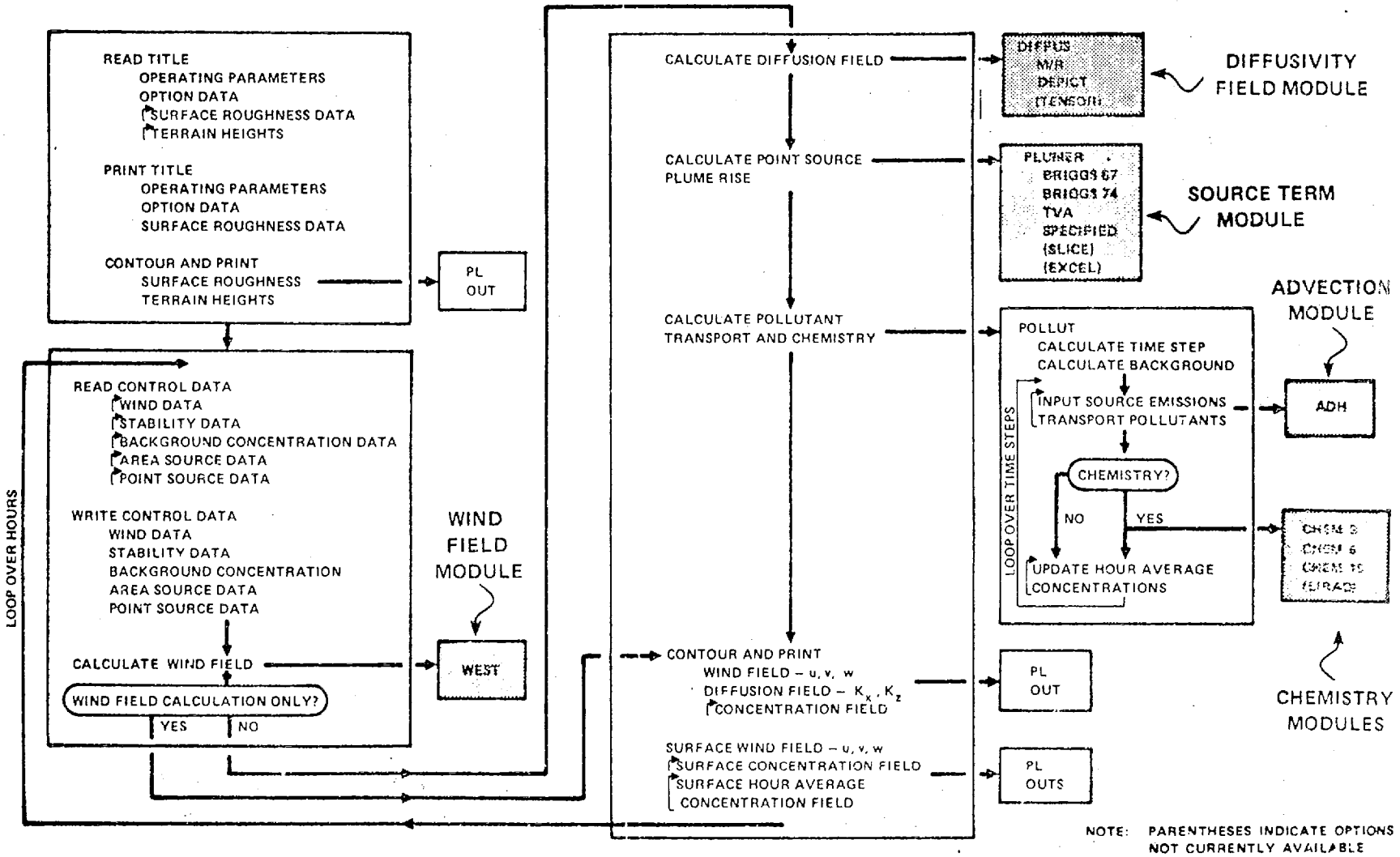

Figure 1. Macro-Flow Diagram of IMPACT.

IMPACT is written in FORTRAN IV and should be transferable to any computer system supporting a FORTRAN IV compiler. It is currently running on IBM 370/108 and DEC-10 systems.

2. PROGRAM ROUTINES

The IMPACT code is designed to solve the following conservation of mass equation:

$$\frac{\partial C_i}{\partial t} = \underbrace{- \frac{\partial u C_i}{\partial x} - \frac{\partial v C_i}{\partial y} - \frac{\partial w C_i}{\partial z}}_{\text{advection}}$$

$$\underbrace{+ \frac{\partial}{\partial x}\left(K_x \frac{\partial C_i}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_y \frac{\partial C_i}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z \frac{\partial C_i}{\partial z}\right)}_{\text{diffusion}}$$

$$\underbrace{+ S_i}_{\text{source term}} \qquad \underbrace{+ \alpha_{ij} C_j + \beta_{ijk} C_i C_j}_{\text{chemistry}}$$

where

C_i = the concentration of the ith pollution species
u, v, w = the three-dimensional flow field vectors
K_x, K_y, K_z = the three-dimensional eddy diffusivity
S_i = the source term for the ith pollutant species
α, β = the chemical rate constants for the first and second order chemical reactions.

A flow diagram, by subroutine, for the IMPACT code is shown in Figure 2. The shaded subroutines represent the major components of the code; the remainder of routines direct program flow and process input and output data. A brief definition and a description of the inputs and outputs for each subroutine in IMPACT is listed in Table 1. A description of the program common block, the five major subroutines, and the input/output routines conclude this section.

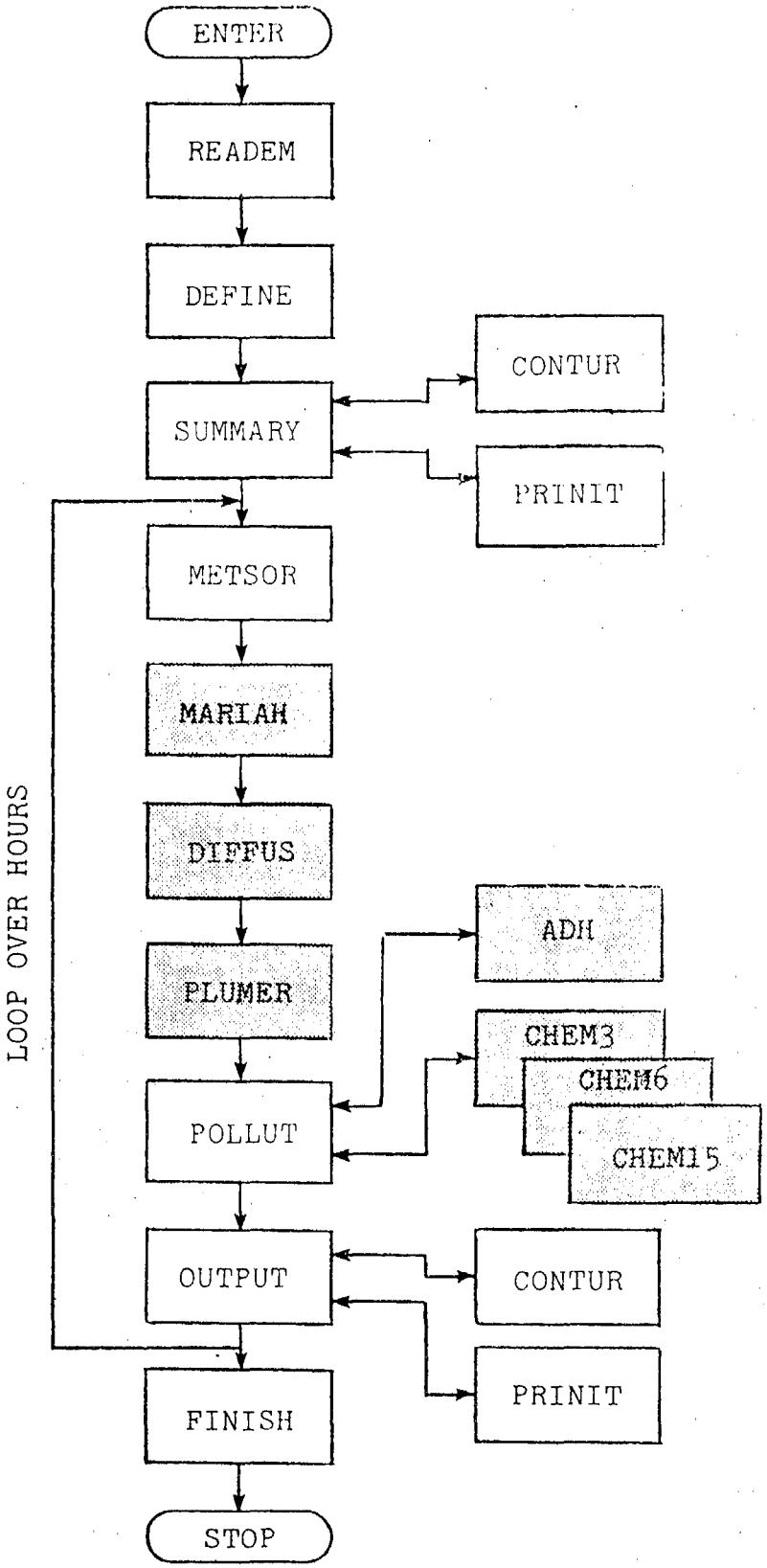

Figure 2. IMPACT Flow Chart.

Table 1. Description of Impact Subroutines.

SUBROUTINE	DESCRIPTION	INPUTS	OUTPUTS
READEM	READ SPACE, TIME INDEPENDENT QUANTITIES, OPTION, ETC.	NONE	GRID SIZE, OPTIONS, ETC.
DEFINE	ESTABLISH USEFUL INVARIANT QUANTITIES FOR LATER PROGRAM EFFICIENCY	GRID SIZE, CELL SIZE, ETC.	$1/\Delta x$, $1/\Delta x^2$, etc.
SUMMARY	PRINT A SUMMARY OF THE INITIAL STATE OF THE SYSTEM; READ TERRAIN AND SURFACE ROUGHNESS DATA	TERRAIN DATA, SURFACE ROUGHNESS DATA, PROGRAM INVARIANTS	INTERGERIZED TERRAIN ARRAY, INTERPOLATED SURFACE ROUGHNESS ARRAY, PRINTS AND EDITS OF INITIAL DATA
CONTUR	PRINT CONTOUR PLOTS FROM ANY SUBMITTED 2-D OR 3-D ARRAY	ANY 2-D OR 3-D ARRAY	CONTOUR PLOTS
PRINTIT	PRINTS THE FIELD ARRAYS TO THE FIRST TWO SIGNIFICANT DIGITS FROM ANY SUBMITTED 2-D OR 3-D ARRAY	ANY 2-D or 3-D ARRAY	PRINTER EDITS
METSOR	HOURLY READS THE METEOROLOGICAL SOURCE AND BACKGROUND DATA. PRINTS SUMMARY OF INPUT DATA. CONVERTS INPUT EMISSIONS FROM G/SEC TO PPM/SEC	WIND, STABILITY, POINT SOURCE, AREA SOURCE, BACKGROUND DATA	NET, SOURCE AND BACKGROUND DATA
MARIAH	CONTAINS THE SUBPROGRAM WEST. INTERPOLATES WIND, STABILITY DATA; CREATES DIVERGENCE-FREE WIND FIELD, CONSISTENT WITH WIND DATA, STABILITY DATA & TERRAIN	WIND AND STABILITY DATA, TERRAIN DATA	CONSISTENT WIND AND STABILITY ARRAYS
DIFFUS	CREATES A DIFFUSIVITY FIELD BASED ON EITHER THE M/R OR DEPICT MODELS	WIND AND STABILITY FIELDS, TERRAIN AND SURFACE ROUGHNESS DATA	DIFFUSIVITY FIELDS
PLUMER	DETERMINES THE POINT SOURCE PLUME RISE BASED ON BRIGGS OR TVA MODELS OR ON USER-SPECIFIED DATA	WIND AND STABILITY FIELDS, TERRAIN, AND POINT SOURCE DATA	POSITION OF THE HORIZONTAL PLUME

Table 1. Description of Impact Subroutines (Continued).

SUBROUTINE	DESCRIPTION	INPUTS	OUTPUTS
POLLUT	CALCULATES POLLUTANT TRANSPORT, DIFFUSION, SOURCES AND CHEMISTRY CALCULATES AVERAGE SURFACE CONCENTRATION	WIND AND DIFFISIVITY FIELDS, EMISSIONS, BACKGROUND CONCENTRATIONS, POSITION OF ELEVATED PLUMES	POLLUTANT CONCENTRATIONS IN TIME AND SPACE
ADH	UPDATES POLLUTANT CONCENTRATIONS DUE TO ADVECTION AND DIFFUSION USING A SECOND-ORDER CROWELY METHOD WITH FLUX CORRECTION	WIND, DIFFUSIVITY, AND CONCENTRATION FIELDS	UPDATED POLLUTANT CONCENTRATION FIELD
CHEM3	CALCULATES THE $SO_2 \rightarrow SO_4$ TRANSFORMATION VIA A MODIFIED DECAY MODEL	POLLUTANT CONCENTRATIONS, FLUXES, AND SOURCES	UPDATED POLLUTANT CONCENTRATIONS
CHEM6	SOLVES THE GRC PHOTOCHEMICAL MODEL USING 6 ACTIVE CHEMICAL SPECIES	POLLUTANT CONCENTRATIONS, FLUXES, AND SOURCES	UPDATED POLLUTANT CONCENTRATIONS
CHEM15	SOLVES THE HECHT-SEINFELD PHOTOCHEMICAL MODEL USING 14 ACTIVE SPECIES	POLLUTANT CONCENTRATIONS, FLUXES, AND SOURCES	UPDATED POLLUTANT CONCENTRATIONS
OUTPUT	PRODUCES A SUMMARY OF THE FIELD ARRAYS CONTOUR AND/OR PRINTER PLOTS AS SPECIFIED IN THE INPUT OPTION DATA	FIELD ARRAYS; WIND, DIFFUSION, STABILITY, CONCENTRATION	PRINTS AND CONTOURS OF FIELD ARRAYS
FINISH	ENDS THE PROGRAM	NONE	PRINTS END OF PROGRAM MESSAGE

2.1 COMMON

There are three blocks of common data used in IMPACT. The first block, /SCALER/, contains all the scaler quantities shared between subroutines. The second block, /ONETWO/, contains all the one and two-dimensional arrays that remain invarient from problem to problem. These common blocks are found in all subroutines except ADH, CHEM3, CHEM6, CHEM15 and FINISH. The third common stock, /TREFOR/, contains the two, three and four-dimensional arrays that may change size from problem to problem. Rather than include this common stock in every subroutine, the common appears only in the main program and is passed to other subroutines via the subroutine call statement. Thus, the user can vary the size of the problem with a minimum of effort. (See section 4.1 for a discussion on modifing the /TREFOR/ common block.)

A glossary of common variables is given in Table 2.

Table 2. Definition of Variables Used in COMMON.

COMMON/SCALAR/

DX = cell size, x-direction
DY = cell size, y-direction
DZ = cell size, z-direction
NX = number of cells, x-direction
NY = number of cells, y-direction
NZ = number of cells, z-direction
NXP1 = NX+1
NYP1 = NY+1
NZP1 = NZ+1
NXM1 = NX-1
NYM1 = NY-1
NZM1 = NZ-1
NUMEWD = number of wind stations
TIMEND = (not currently implemented)
NUMCEM = number of chemicals
NUMESD = number of stability profile locations
NUMHRS = number of hours simulated
NUMEPS = number of point sources
NUMASD = number of area sources
NOWTIM - current hour
IDOWND = wind model flag
IDOCEM = chemistry model flag
IDODIF = diffusion model flag
IDOPLT = surface plot flag
NUMBCP = number of background concentration points
TGRND = temperature of ground
SOLAR = flux
PRESR = ambient pressure
AMBCO = CO concentration, ppm
AMH_2O = water vapor concentration, ppm
SIMTIM = same as NOWTIM
IDOPRN = print flag
IDOCAL = Calcomp plotter flag
IDT = number of time steps per hour
HRSAVG = number of hours to be averaged
DXI2 = $1/DX^2$
DYI2 = $1/DY^2$
DZI2 = $1/DZ^2$
DXI = 1/DX
DYI = 1/DY
DZI = 1/DZ
NS = number of species
NUMSRD = number of surface roughness data
IDOPLM = plume rise model flag
DT = time step size
IDOSUR = surface plot flag

DX2 = DX^2
DY2 = DY^2
DZ2 = DZ^2
NOWEWD = time at which next wind station data read
NOWESD = time at which next stability profile data read
NOWEPS = time at which next point source data read
NOWASD = time at which next area source data read
NOWBCP = time at which next background concentration data read

COMMON/ONETWO/

EPS = point source emission array
UDH = specified plume rise array
DH = plume rise array
CC = cellular concentration
SS = cellular source array
ISKIP = subroutine control flag array
IEW = I-location of wind data
JEW = J-location of wind data
EWS = wind speed array
EWD = wind direction array
EWW = wind-weight array
WV = measured wind speed, v-direction
IES = I-location of stability data
JES = J-location of stability data
ESS = stability profile array
WU = measured wind speed, u-direction
IBC = I-location of background concentration
JBC = J-location of background concentration
EBC = background concentration array
IPS = I-location of source
JPS = J-location of source
KPS = K-location of source
IZO = I-location of surface roughness
HPS = stack height array
TPS = stack gas temperature array
VPS = stack volume flow array
DPS = stack diameter array
SPS = exhaust velocity of stack
ISS = I-location of stack
JSS = J-locations of stack
SSS = (not implemented)
TITLE = title of run
TITL = titles of field arrays
JZO = J-location of surface roughness
ZO = surface roughness array
ILAS = low I-location of area source
IHAS = high I-location of area source
JLAS = low J-location of area source
JHAS = high J-location of area source
EAS = area source emission array

CEMNAM = chemistry array
EPST = point source emission array
EAST = area source emission array

COMMON /TREFOR/

C = concentration array
CA = averaged surface concentration array
CT = temporary concentration array
U = u-velocity
V = v-velocity
W = w (vertical) velocity
EX = horizontal diffusivity x-direction
EY = horizontal diffusivity y-direction
EZ = vertical diffusivity z-direction
STAB = stability array
HT = terrain height array
ZO = surface roughness array
IHT - integerized height array

2.2 WEST WIND FIELD MODEL - SUBROUTINE MARIAH

IMPACT is designed to be used with as little or much data as is available, since possible applications range from unmonitored wilderness to intensively instrumented research areas. Thus, the wind field uses any and all available data, with its accuracy improving with increased, usable data.

The wind field development is diagramed in Figure 3. Atmospheric stability data are interpolated via a $1/r^4$ weighting to produce a stability field over the computational domain (1.0 = A stability 7.0 = G stability). Wind observations are projected upwards from the point measured through the portion of the grid without any measurement. Such projected data are weighted as 0.001 compared with user-specified weighting of from 1.0 to 0.0.

The projections are based on a power law extrapolation of the form

$$S = S_o \ (Z/Z_o)^P$$

for speeds S and S_o at vertical coordinates Z and Z_o, respectively, with P determined by linear interpolation from the following table:

Stability Category	A 1	B 2	C 3	D 4	E 5	F 6	G 7
P	.15	.17	.20	.26	.39	.48	.54

The maximum wind speed allowed is 20 m/sec and the initial Z_o is assumed equal to $\Delta Z/2$. After the wind speeds are projected upwards, the wind speed and direction are resolved into U and V vector components at every wind data site. Next, the entire wind field is developed via a weighted $1/r^2$ interpolation of the vertical profiles for each horizontal plane. Up to this point, terrain has not been considered. Terrain first enters by shifting

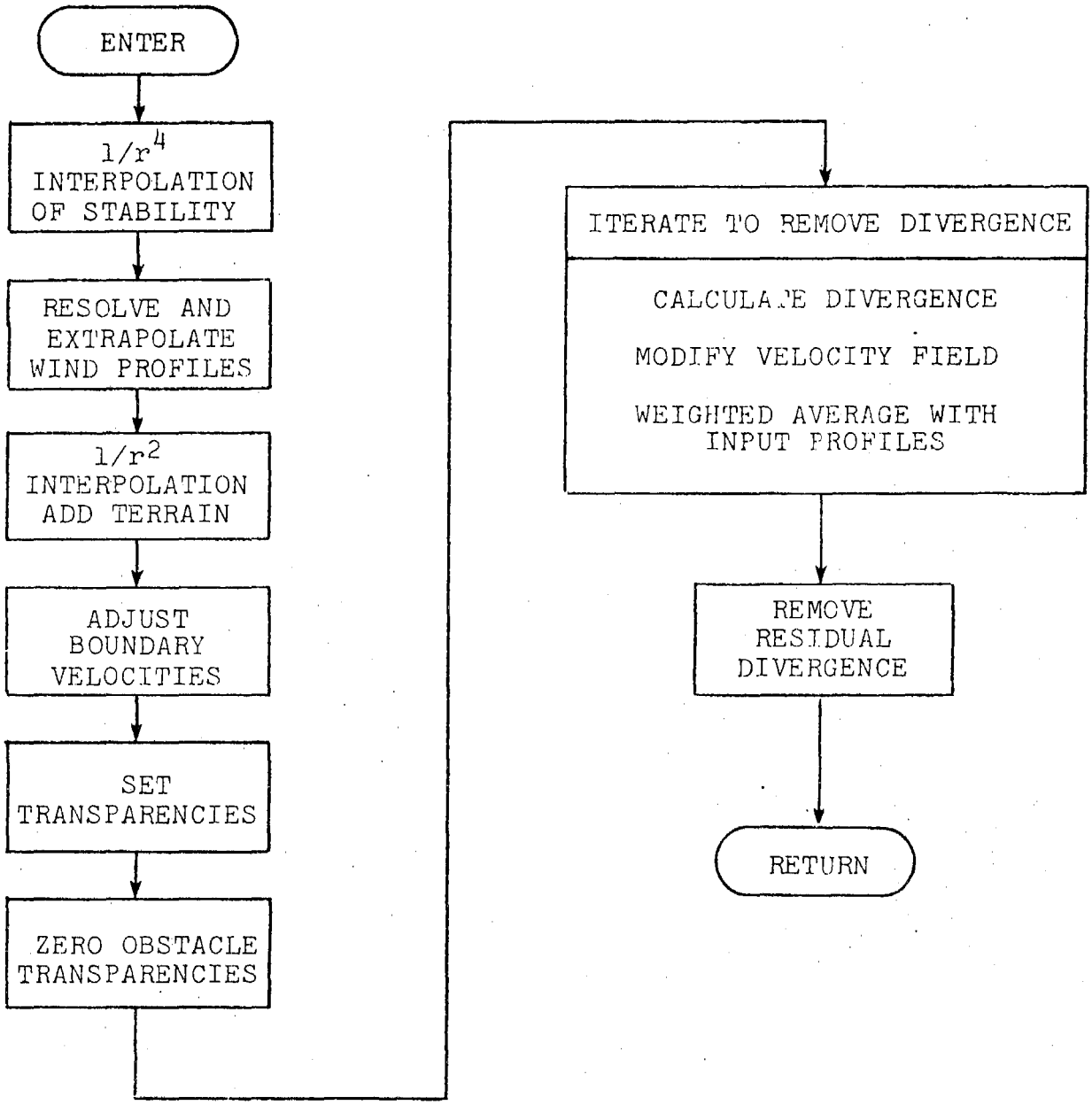

Figure 3. MARIAH Flow Diagram.

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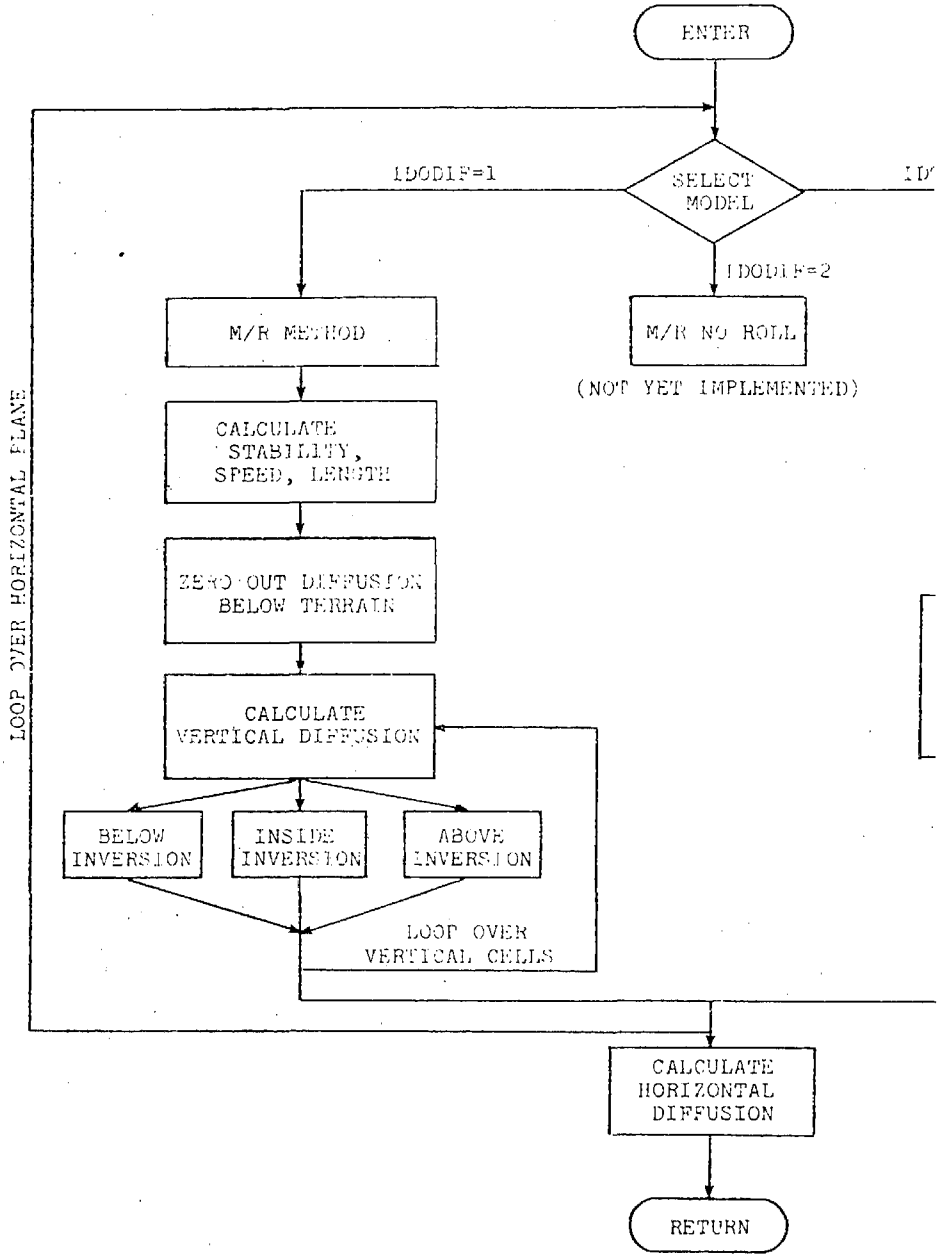


Figure 4. DIFFUS Flow Diagram.

where

Z is the height above the ground
L is the Monin-Obukhov length and
U_* is the friction velocity

$$U_* = (0.35)\ U_o/(m(Z_w/Z_o) + 4.7\ (Z_w - Z_o)/L) \text{ for } L \geq 0$$

and

$$U_* = (0.35)\ U_o/\{m((Z'_w - 1.0)/(Z'_w + 1.0)) + 2.0\ \tan^{-1}(Z'_w) - ((Z'_o - 1.0)/(Z'_o + 1.0)) - 2.0\ \tan^{-1}(Z'_o)\} \text{ for } L < 0$$

$$Z'_w = (1.0 - 15\ Z_w/L)^{1/4}$$

$$Z'_o = (1.0 - 15\ Z_o/L)^{1/4}$$

U_o is wind speed at a height Z_w above the surface and
$Z_w = \Delta Z/2$

The vertical diffusivity D is further modified by the function

$$D = D + (1.1 - Z/ZIBSE)$$

when

$$0.1 * ZIBSE < Z < 1.1 * ZIBSE$$

For the second case (inside an elevated inversion), the surface wind speed is set to 3.0 m/sec, the Monin-Obukhov length is set to 20.0, and Z (the height above the surface) is measured from ZIBSE.

Above the elevated inversion, the third case, neutral stability is assumed and Z is measured from the top of the inversion ZITOP. The vertical diffusion is then limited by $0.001\ m^2/sec \leq D \leq 1000\ m^2/sec$ and assigned to the top face of the cell.

The vertical diffusivity as calculated by the DEPICT model (Smith, 1971) is more straightforward.

$$D = (.45)\ \bar{U}\ \sigma_\varepsilon \ell$$

where

$\bar{U}$ is the wind speed at the point of interest

σ_ε is the standard deviation of the wind vane fluctuation - σ_ε is empirically related to stability as follows:

Stability	1	2	3	4	5	6
σ_ε	.262	.237	.184	.119	.056	.023

ℓ is the turbulence length scale (meters) and is empirically related to stability as follows:

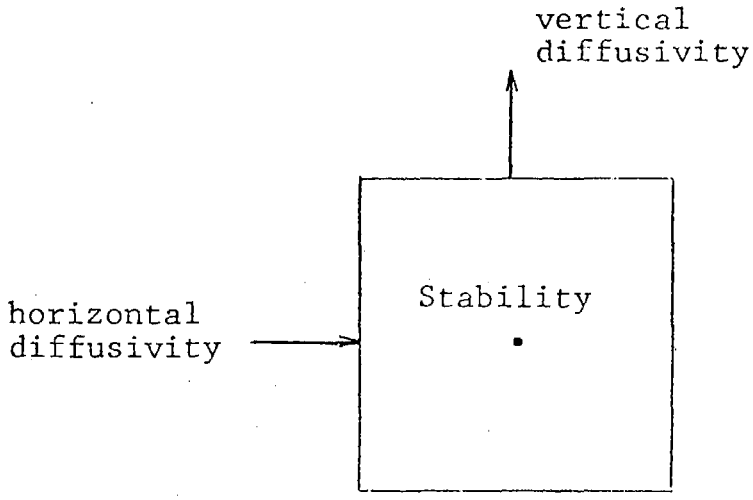
Stability	1	2	3	4	5	6
ℓ	105	85	74	64	59	54

The horizontal diffusivities are calculated for either diffusion option using the relation $D_H = \alpha D_V$ where α depends on on stability as follows:

Stability	1	2	3	4	5	6
α	.5	.75	1.05	1.35	1.70	2.0

(See Figure 4-11 in the main report.)

The location of the related stability vertical diffusivity and horizontal diffusivity parameters are indicated below:



Because the diffusivities are face-centered, the vertical stability is offset one-half cell above the cell center; the horizontal diffusivity is offset one-half cell to the left of the cell center.

2.4 PLUME RISE MODELS - SUBROUTINE PLUMER

The user is given the option of selecting the Briggs 1974 plume rise model, the Briggs 1967 plume rise model, or the TVA plume rise model; or specifying either $U(\Delta h)$ or Δh. A flow diagram of PLUMER is shown in Figure 5. The subroutine loops over each source and checks whether or not the source is inside the grid. If the source is outside the grid, an error message is printed and that source is ignored. If the user has specified ΔH (IDO PLM = 8), the total plume rise ($H + \Delta H$) is determined and the cell in which to insert the point source emissions is calculated. If $U(\Delta h)$ is specified (IDOPLM = 7), the velocity at the top of the stack is calculated and $\Delta H = U\Delta H/U$. For either Briggs model (IDOPLM = 1,2) and the TVA model (IDOPLM = 3), the buoyancy parameter F and the temperature gradient at the top of the stack are determined. The plume rise Δh is calculated as described in the following paragraphs.

TVA 1974

Buoyancy $F = gV\ (T_o - T_a)/T_o$

where

- g is the gravitation acceleration (9.8 m/sec^2)
- V is the initial volume flux divided by π (m^3/sec) (also equal to wr^2 where w is the exit velocity and r is the stack inside radius)
- T_o is the stack gas temperature (^oK)
- T_a is the ambient temperature at the stack (^oK) for neutral and stable conditions.

For a distance of 1824 meters (a presumed final rise) the plume rise is calculated from

$$\Delta h = 173\ \frac{F^{1/3}}{u}\ \exp\ (-64\ (\partial T/\partial z + 0.01))$$

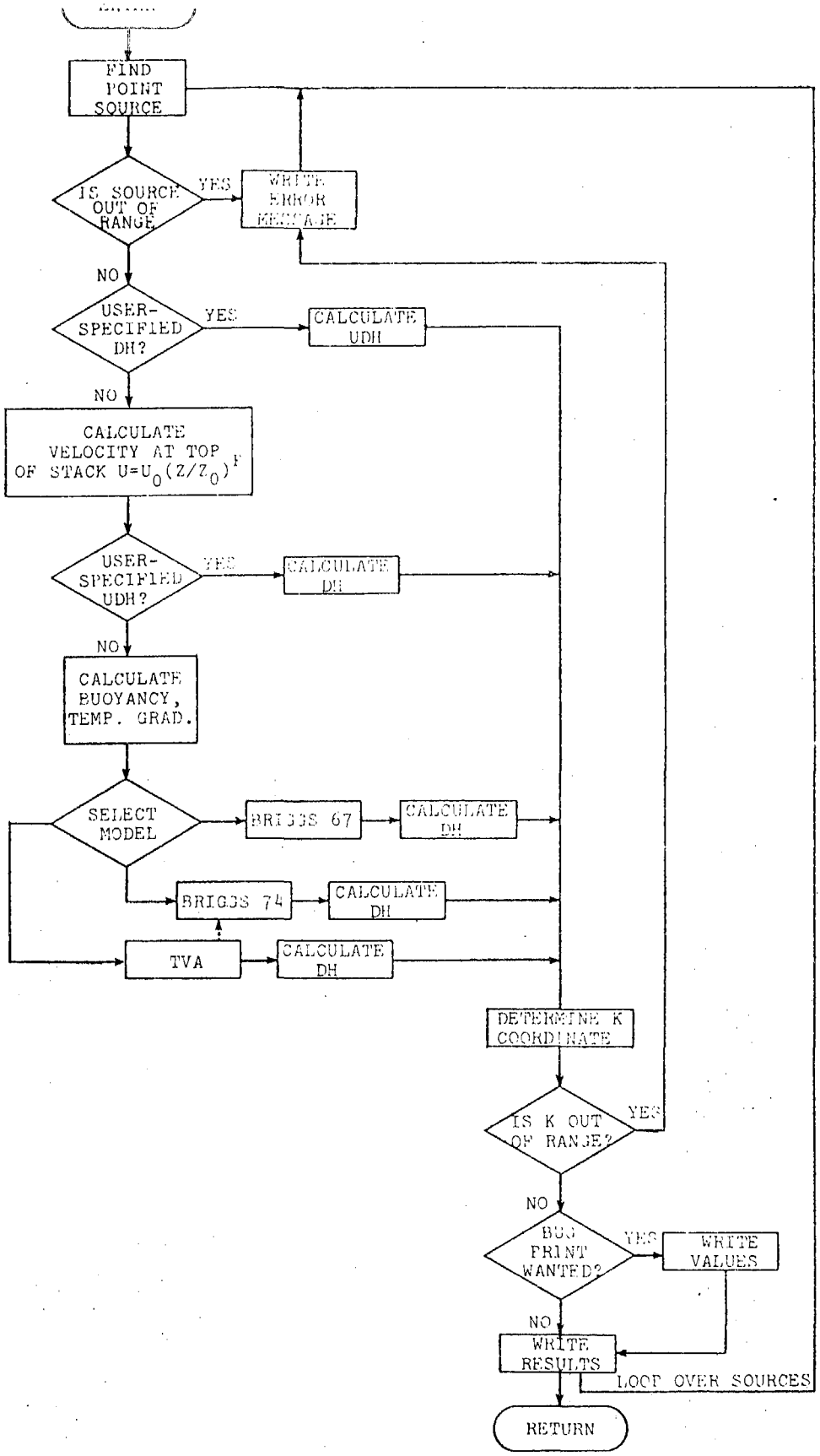


Figure 5. Plumer Flow Diagram.

Briggs 1967

Neutral and Unstable (A-D)

$$\Delta h = 1.6 \frac{F^{1/3}}{u} (10\ h_s)^{2/3}$$

where h_s is the stack height

Stable Conditions (E-F)

$$\Delta h = 2.9 \left(\frac{F}{us}\right)^{1/3} \text{ where } s = \frac{g}{T_a} \left(\frac{\partial T}{\partial z} + 0.01\right)$$

Briggs 1974

Neutral and Unstable (A-D)

$$\Delta h = 1.6 \frac{F^{1/3}}{u} (3.5\ x^*)^{2/3}$$

where

$$x^* = 14\ F^{5/8} \text{ for } F \leq 55$$
$$x^* = 34\ F^{2/5} \text{ for } F > 55$$

Stable Conditions (E-F)

$$\Delta h = 2.6 \left(\frac{F}{us}\right)^{1/3} \text{ where } s = \frac{g}{T_a} \left(\frac{\partial T}{\partial z} + 0.01\right)$$

2.5 POLLUTANT TRANSPORT - SUBROUTINES POLLUT, ADH

The transport, dispersion and transformation of pollutants is controlled by the subroutine POLLUT. Each call to POLLUT advances the simulation one hour. A flow diagram of POLLUT is shown in Figure 6.

The advection/diffusion time step is calculated such that the maximum normalized flux across any cell is less than alpha, i.e.:

$$\Delta t = \alpha/(u/\Delta x + kx/\Delta x^2)$$

If the time step is too large or too small, an error message is printed and the program stops. The time step is further adjusted such that N advection cycles end exactly on the hour.

The subroutine then loops over N time steps

($\Delta t \cdot N = 3600$ seconds)

If multiple species chemistry is requested, POLLUT checks to see if each cell is either below terrain or contains a significant amount of tracer concentration. If not, the background concentration is loaded into the cell. This procedure forces those cells not affected by point or area sources to agree with the observed background concentration distribution.

The concentrations are stored in a temporary array and then advected/diffused in the X, Y, Z direction via sucessive calls to subroutine ADH. Point and area source emissions are added. If multiple species chemistry is selected, the updated concentrations in each cell are subtracted from the stored (old) concentrations to determine the flux into each cell. If there is sufficient tracer concentration in the cell ($>10^{-3}$ $\mu g/m^3$), the appropriate chemistry subroutine (CHEM 3, CHEM 6, CHEM 15) is called and returns with the updated concentration.

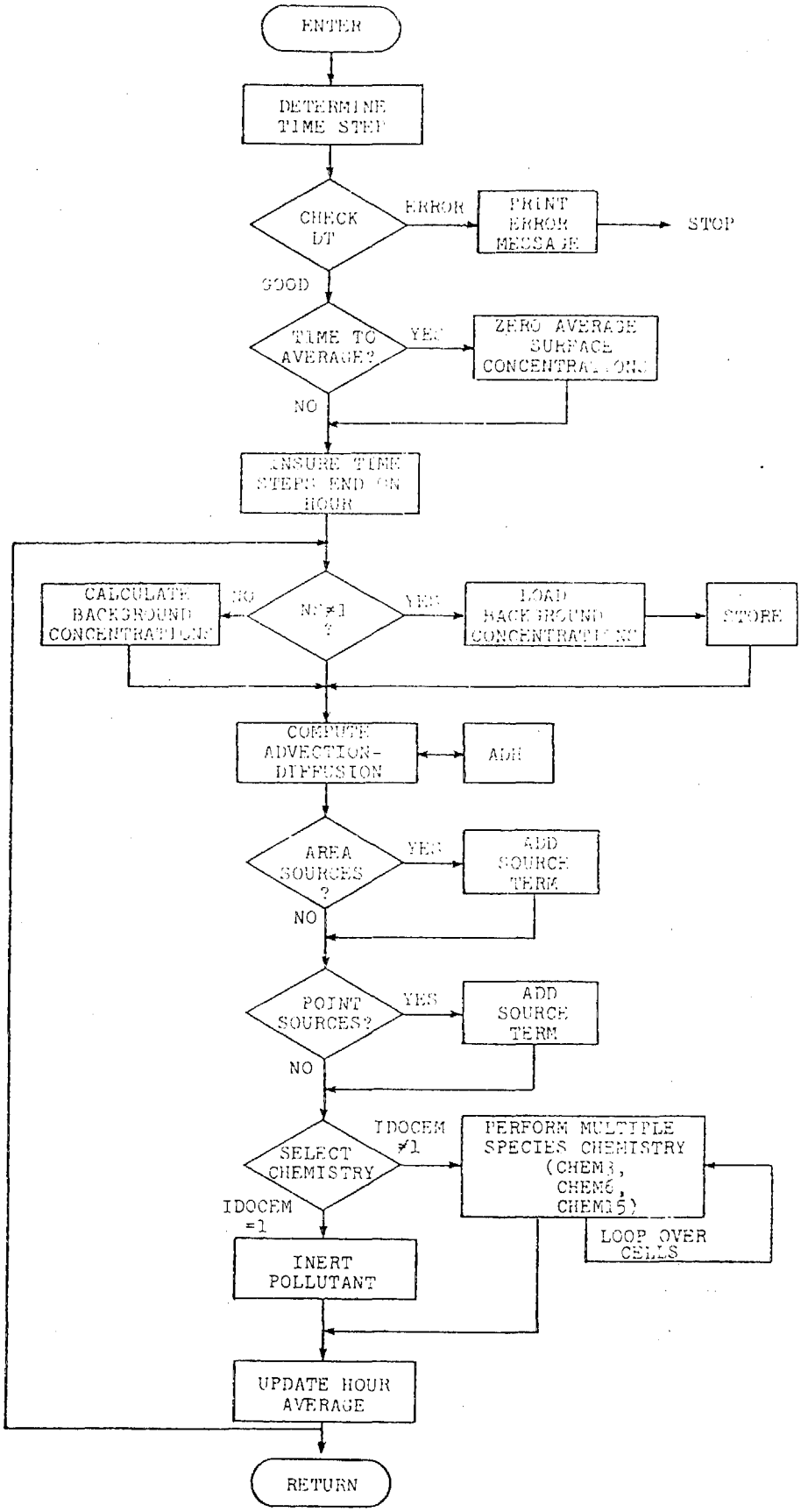


Figure 6. POLLUT Flow Diagram.

Finally, surface concentrations are accumulated to calculate the hour-averaged concentration field.

Subroutine ADH solves the differential equation describing advection and diffusion of pollutant concentration, i.e.:

$$\frac{\partial C}{\partial t} = -\nabla \cdot UC + \nabla \cdot K \cdot \nabla C$$

The solution is performed seperately in each direction with the form

$$\frac{\partial C}{\partial t} = -\frac{\partial UC}{\partial x} + \frac{\partial}{\partial x} K_x \frac{\partial C}{\partial x}$$

The finite difference solution is based on a flux-corrected version of Crowely's second-order advection scheme

$$C_i^{n+1} = C_i^n + \frac{F_{i-\frac{1}{2}}^n - F_{i+\frac{1}{2}}^n}{\Delta x} \Delta t$$

where

$$F_{i+\frac{1}{2}}^n = \frac{\Delta x}{2\Delta t} \left\{ (C_i^n + C_{i+1}^n)\, \alpha_{i+\frac{1}{2}} + (C_i - C_{i+1})\, \alpha_{i+\frac{1}{2}}^2 \right\}$$

$$+ K_{xi+\frac{1}{2}} (C_i - C_{i+1})/\Delta X$$

and

$$\alpha_{i+\frac{1}{2}} = \frac{U_{i+\frac{1}{2}} \Delta t}{\Delta X}$$

The flux corrector prohibits the calculation of negative concentrations by an adjustment of the flux, as follows:

if

$$F_{i+\frac{1}{2}} \geq 0$$

then

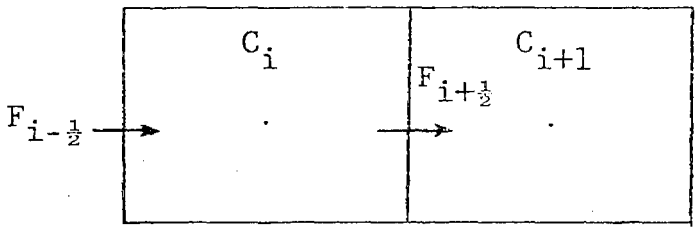
$$F_{i+\frac{1}{2}} = \min \left(F_{i+\frac{1}{2}}, \frac{\Delta x}{\Delta t} C_i, \frac{\Delta x}{\Delta t} C_i + F_{i-\frac{1}{2}}\right)$$

if

$$F_{i+\frac{1}{2}} < 0$$

then

$$F_{i+\frac{1}{2}} = \min \left(-F_{i+\frac{1}{2}}, \frac{\Delta x}{\Delta t} C_{i+1}\right)$$



2.6 CHEMISTRY - SUBROUTINES CHEM 3, CHEM 6, CHEM 15

The IMPACT code is designed to provide the framework for simulating the complex chemical transformations of air pollutants, as well as the transport and dispersion of simple inert pollutants. Three chemical reaction mechanisms are available as options in the present version of IMPACT. The input format to all chemistries are the same: the cellular concentrations before the current advection/diffusion step, C(N); the input (or output) flux due to the current advection, diffusion, and emissions, S(N); and the advection/diffusion time step, Δt. In addition, the two photochemistry models require the solar flux, SOL, as input. All chemistries return the pollutant concentrations at the new time $T = T + \Delta T$ via the cellular concentration array C(N).

Two chemical reaction mechanisms simulate the transformation of the constituents of photochemical smog. A simple mechanism developed by GRC (Eschenroder, 1972), CHEM6 supports five active species including NO_2, NO, O_3, and HC (non-methane reactive hydrocarbon and HNO_2). CHEM6 is limited to simulations of 12 hours or less (see Table 3). The other photochemical model, CHEM15, incorporates the latest EPA-recommended mechanisms (Hect-Seinfeld, 1974), and supports 14 active species including NO_2, NO, O_3, HC1 (olefins), HC2 (aromatics), HC3 (parafins), HC4 (aldehydes), N_2O_5, HNO_3, HNO_2, HO_2, H_2O_2, ROO, and RCOO (see Table 4).

Both CHEM6 and CHEM15 express the effects of chemical reactions and sources by a solution for each cell of a rate equation of the form

$$\frac{\partial C_1}{\partial t} = A_1 + \sum_{n=1}^{N} B_{1n} C_n + \sum_{n,m=1}^{N} D_{1nm} C_n C_m$$

Table 3. CHEM6 Reaction Mechanism.

	REACTION MECHANISM	RATE CONSTANT (ppm/min)
1.	$h\upsilon + NO_2 \rightarrow NO + O$	2.67×10^{-1}
1a.	$O + O_2 + M \rightarrow O_3 + M$	$2. \times 10^{6}$
2.	$NO + O_3 \rightarrow NO_2 + O_2$	2.67×10
3.	$O + HC \rightarrow (b_1)\ RO_2$	2.67×10^{2}
4.	$OH + HC \rightarrow (b_2)\ RO_2$	$1. \times 10^{4}$
5.	$O_3 + HC \rightarrow (b_3)\ RO_2$	$4. \times 10^{-3}$
6.	$RO_2 + NO \rightarrow NO_2 + (y)\ OH$	$1. \times 10^{5}$
7.	$RO_2 + NO_2 \rightarrow PAN$	$2. \times 10^{2}$
8.	$OH + NO \rightarrow HONO$	1.5×10^{3}
9.	$OH + NO_2 \rightarrow HNO_3$	$3. \times 10^{3}$
10.	$h\upsilon + HONO \rightarrow OH + NO$	1.5×10^{-3}
11.	$NO + NO_2 \xrightarrow{H_2O} 2\ HONO$	$1. \times 10^{-3}$
12.	$NO_2 + O_3 \rightarrow NO_3 + O_2$	$5. \times 10^{-3}$
13.	$NO_3 + NO_2 \rightarrow N_2O_5$	4.5×10^{3}
14.	$N_2O_5 \rightarrow NO_3 + NO_2$	1.4×10
15.	$N_2O_5 + H_2O \rightarrow 2HNO_3$	6.05×10
16.	$NO_2 + PARTICULATES \rightarrow PRODUCTS$	0.0

Table 4. CHEM15 Reaction Mechanism.

	REACTION MECHANISM	RATE CONSTANT (ppm/min)
1.	$NO_2 + h\upsilon \rightarrow NO + O$	2.66×10^{-1}
2.	$O + O_2 + M \rightarrow O_3 + M$	$2. \times 10^{-5}$
3.	$O_3 + NO \rightarrow NO_2 + O_2$	2.08×10^{1}
4.	$O + NO + M \rightarrow NO_2 + M$	3.5×10^{-3}
5.	$O + NO_2 \rightarrow NO + O_2$	1.38×10^{4}
6.	$O + NO_2 + M \rightarrow M \rightarrow NO_3 + M$	2.2×10^{-3}
7.	$O_3 + NO_2 \rightarrow NO_3 + O_2$	4.6×10^{2}
8.	$NO_3 + NO \rightarrow 2NO_2$	1.5×10^{4}
9.	$NO_3 + NO_2 \rightarrow N_2O_5$	4.5×10^{3}
10.	$N_2O_5 \rightarrow NO_2 + NO_3$	1.5×10
11.	$N_2O_5 + H_2O \rightarrow 2HNO_3$	$1. \times 10^{-5}$
12.	$NO + HNO_3 \rightarrow HNO_2 + NO_2$	2.5×10^{-4}
13.	$HNO_2 + HNO_3 \rightarrow H_2O + 2NO_2$	$2. \times 10^{-1}$
14.	$NO + NO_2 + H_2O \rightarrow 2HNO_2$	2.1×10^{-6}
15.	$2HNO_2 \rightarrow NO + NO_2 + H_2O$	4.5
16.	$HNO_2 + h\upsilon \rightarrow OH + NO$	1.3×10^{-2}
17.	$OH + NO_2 \rightarrow HNO_3$	1.5×10^{4}
18.	$OH + NO + M \rightarrow HNO_2 + M$	1.2×10^{4}
19.	$OH + CO + (O_2) \rightarrow CO_2 + HO_2$	2.5×10^{2}
20.	$HO_2 + NO \rightarrow OH + NO_2$	$7. \times 10^{2}$
21.	$H_2O_2 + h\upsilon \rightarrow 2OH$	2.5×10^{2}
22.	$HC_1 + O \rightarrow ROO + \alpha RCOOO + (1-\alpha)\, HO_2$	6.8×10^{3}
23.	$HC_1 + O_3 \rightarrow RCOOO + RO + HC_4$	1.6×10^{-2}
24.	$HC_1 + OH \rightarrow ROO + HC_4$	2.5×10^{4}
25.	$HC_2 + OH \rightarrow ROO + OH$	1.07×10^{2}
26.	$HC_2 + OH \rightarrow ROO + H_2O$	$8. \times 10^{3}$
27.	$HC_3 + O \rightarrow ROO + OH$	6.5×10
28.	$HC_3 + OH \rightarrow ROO + H_2O$	3.8×10^{4}
29.	$HC_4 + h\upsilon \rightarrow \beta ROO + (2-\beta)\, HO_2$	2.5×10^{-3}
30.	$HC_4 + OH \rightarrow \beta RCOOO + (1-\beta)\, HO_2 + H_2O$	2.3×10^{4}
31.	$ROO + NO \rightarrow RO + NO_2$	9.1×10^{2}
32.	$RCOOO + NO + (O_2) \rightarrow ROO + NO_2\, CO_2$	9.1×10^{2}
33.	$RCOOO + NO_2 \rightarrow RCOOO\, NO_2$	$1. \times 10^{2}$
34.	$RO + O_2 \rightarrow HO_2 + HC_4$	2.4×10^{-2}
35.	$RO + NO_2 \rightarrow RONO_2$	4.9×10^{2}
36.	$RO + NO \rightarrow RONO$	2.5×10^{2}
37.	$HO_2 + HO_2 \rightarrow H_2O_2 + O_2$	5.3×10^{3}
38.	$HO_2 + ROO \rightarrow RO + OH + O_2$	$1. \times 10^{2}$
39.	$2ROO \rightarrow 2RO + O_2$	$1. \times 10^{2}$

HC_1 = olefins, HC_2 = aromatics, HC_3 = parafins, HC_4 = aldehydes

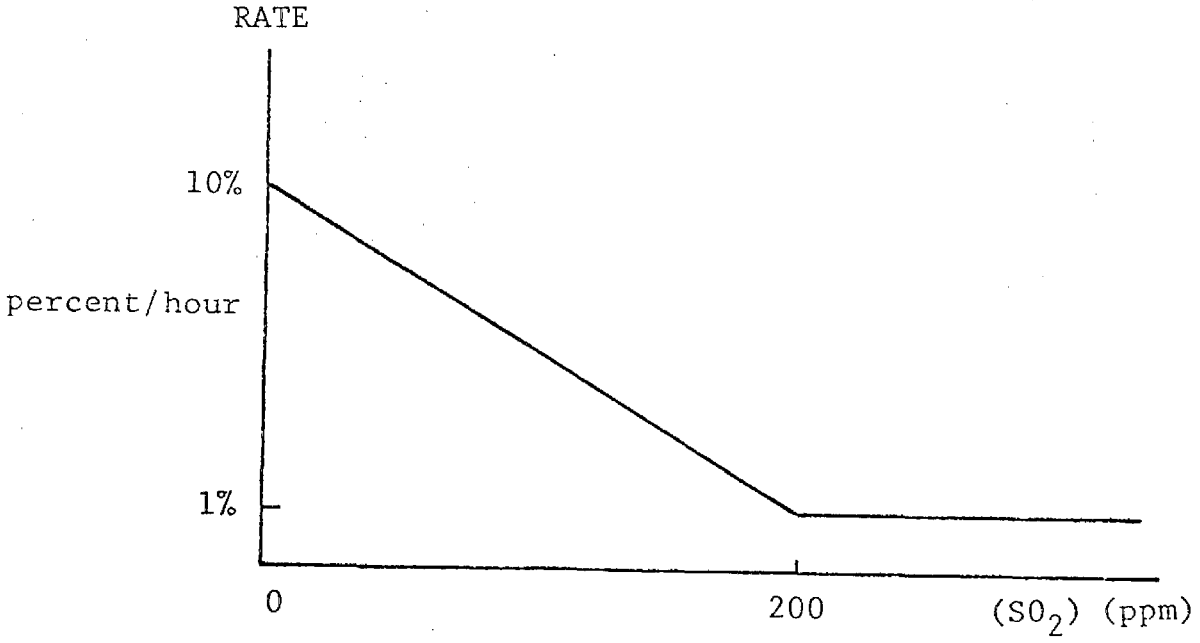
for the 1th pollutant species. The A_1 factor is used to enter sources and the net advective/diffusive flux into the cell. The rate equation is recast into

$$\frac{\partial C_1}{\partial t} = F_1 - R_1 C_1$$

and an approximate solution, used as a predictor-corrector, is

$$C_1^{n+1} = - F_{1/R_1} + \left(C_1^n + F_{1/R_1}\right)^{-R_1 \Delta t}$$

The third chemistry option (CHEM 3) is a simplified treatment of the oxidation of sulfer dioxide to sulfate. The SO_2 mechanism currently encoded in IMPACT does not simulate SO_2 photochemistry but rather relies upon empirical observation of atmospheric SO_2 oxidation rates. Observed maximum rates have been found to range from 2 percent per hour to 12 percent per minute. The SO_4 mechanism in IMPACT employs a spatially-dependent SO_2 to SO_4 conversion rate that depneds upon the plume concentration at the point under consideration as shown below.



2.7 INPUT/OUTPUT ROUTINES

Four subroutines control the input and output of IMPACT. Subroutine READEM reads and writes the initial invariant input data. Subroutine SUMMARY reads and processes the terrain and surface roughness data and prints a summary of the invariant data. Subroutine METSOR reads the hourly wind, stability, point source, area source, background concentration, and global parameters (solar flux, surface temperature, etc.). Emissions data (except for the tracer) are transformed from g/sec to ppm/sec and a summary of the hourly input data is printed. Subroutine OUTPUT controls the printing of the results of the IMPACT calculations. Printer edits and contours of winds, diffusivity, stability, and concentration arrays can be printed level-by-level or for surface values only. The surface array of hour-average concentrations can also be printed.

Subroutine CONTUR creates a printer contour plot from any submitted array with less than 45 cells in the x-direction. Subroutine PRINIT prints the first two significant digits of any submitted array with less than 40 cells in the x-direction.

3. PROGRAM OPTIONS

IMPACT allows the user to select the size and resolution of the simulation problem. However, due to the size of dimensioned arrays in the COMMON/ONETWO/ block and the formats in the output subroutines CONTUR and PRINIT, the following limitations apply:

- NX - the number of cells in the x-direction must be ≤ 40
- NZ - the number of cells in the y-direction must be ≤ 20
- NUMEWD, NUMESD, NUMEPS, NUMASD, NUMBCP and NUMSRD - the number of wind, stability, point source, area source, background, and surface roughness data sites (respectively) cannot be greater than 50 each.

Other than these conditions, only computer storage and run time considerations restrict the size and resolution of the problem. The time-dependent options allow the user to select the number of hours to be simulated (NUMHRS), and the interval (in multiples of one hour) for which time-averaged surface concentrations are calculated (HRSAVG). The user may also specify the time interval (in multiples of one hour) for the printer edit and printer contour output (IDOPRN, IDOPLT).

By selecting the appropriate input options, the user can specify the models to be used in calculating variables listed below:

IDOCEM = 0	wind and diffusion field calculations only
IDOCEM = 1	tracer only
IDOCEM = 3	tracer plus SO_2, SO_4 sulfate chemistry
IDOCEM = 6	tracer plus photochemistry, GRC photochemical model
IDOCEM = 15	tracer plus photochemistry, Hect-Seinfeld photochemical model
IDODIF = 1	Myrup/Ranzieri diffusivity model
IDODIF = 3	DEPICT diffusivity model

IDOPLM = 1	Briggs 1967 plume rise model
IDOPLM = 2	Briggs 1974 plume rise model
IDOPLM = 3	TVA plume rise model
IDOPLM = 7	user-specified $U\Delta h$ plume rise parameter
IDOPLM = 8	user-specified plume rise Δh.

4.2 INPUT FILE STRUCTURE

The input file for IMPACT is illustrated in Figure 7. Title, grid size, options, output, terrain, and surface roughness data are temporally invariant and are entered at the start of the simulation. Other inputs (wind, stability, point source, area source, background concentrations, and global atmospheric parameters) must be read in for each hour of simulation.

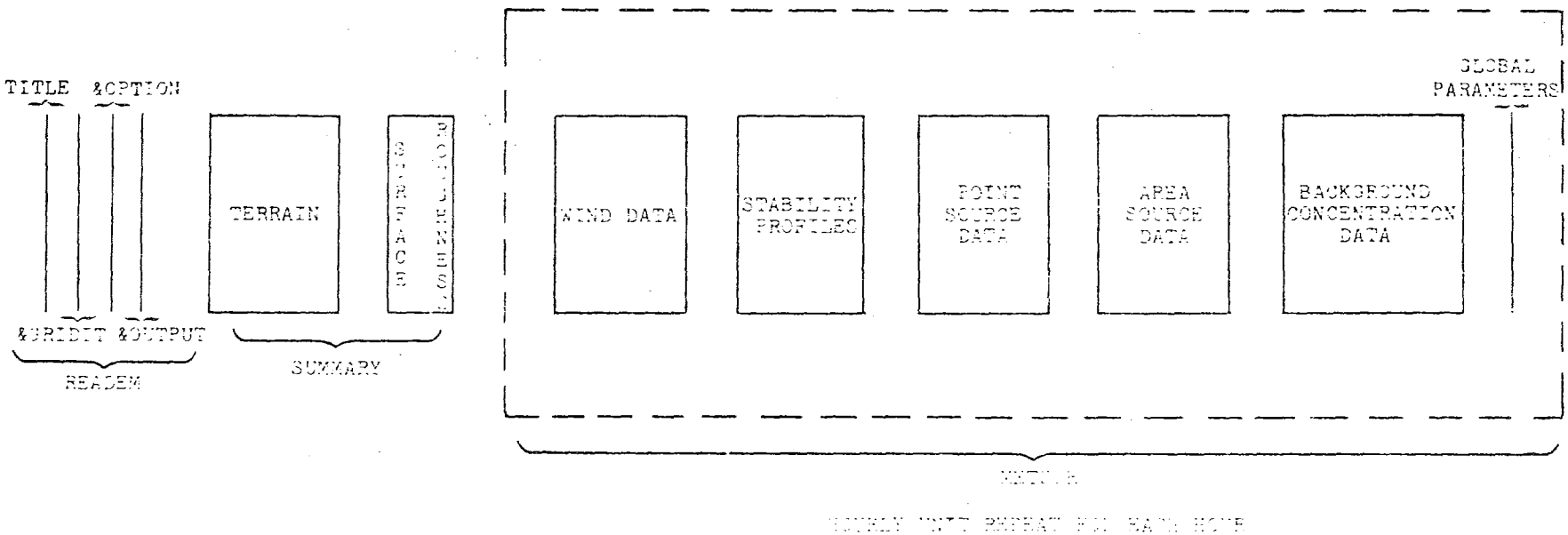


Figure 7. Data File Structure Indicating Calling Routines.

4.3 INPUT FILE DESCRIPTION

This section contains a record-by-record description of the input file required to run IMPACT.

Three records are read in using the NAMELIST convention (GRIDIT, OPTION, OUTPUT). The remaining records are transfered under format control.

The input records are described below in the order shown in Figure 7.

4.3.1 Title

The title record consists of up to 80 characters that identify the particular run read in under a 20A4 format.

4.3.2 & GRIDIT

This namelist record describes the size and resolution of the problem.

DX:
DY:
DZ: } specifies the cell size in meters (east-west, north-south, and vertical).

NX:
NY:
NZ: } specifies the number of grid cells in the x, y, z-directions.

4.3.3 & OPTION

This namelist record describes the options requested for wind field, chemistry, point source, plume rise and diffusion model

IDOWND: selects wind field model IDOWND = 1 WEST

IDOCEM: selects the chemistry model

- IDOCEM = 0 no pollutants, wind and diffusion field calculation only
- IDOCEM = 1 no chemistry, single tracer pollutant (NS = 1)

IDOCEM = 3 sulfate chemistry (NS = 3)

IDOCEM = 6 GRC photochemistry (NS = 6)

IDOCEM = 15 EPA photochemistry (NS = 15)

IDOPLM: selects the plume rise option

IDOPLM = 1 Briggs 69 plume rise

IDOPLM = 2 Briggs 74 plume rise

IDOPLM = 3 TVA plume rise

IDOPLM = 7 user-specified $U\Delta H$

IDOPLM = 8 user-specified ΔH

IDODIF: selects the diffusivity model option

IDODIF = 1 Myrup/Ranzieri diffusivity model

IDODIF = 3 DEPICT diffusivity model

4.3.4 & OUTPUT

This namelist record describes the total number of hours to be simulated and the output options desired.

NUMHRS: the number of hours to be simulated by IMPACT

IDOPLT: the frequency in integer hours for printer contour output

IDOPLT = 0 no printer contour desired

IDOPLT = 1 printer contours every hour

IDOPLT = 3 printer contours every 3 hours plus first hour (i.e. hours 1, 3, 6...)

IDOPRN: the frequency in integer hours for printer edit output

IDOPRN = 0 no printer edits desired

IDOPRN = 1 printer edit every hour

IDOPRN = 3 printer edit every 3 hours plus first hour

IDOCAL: option for calcomp plots of wind field vectors and pollutant concentration contours - not currently implemented, set IDOCAL = 0

HRSAVG: the integer number of hours desired for calculating average surface concentration

HRSAVG = 1 one-hour average concentrations desired, printed every hour (IDOPRN, IDOPLT should also be set to 1)

HRSAVG = 3 three-hour average concentrations desired, printed every third hour (3, 6, 9...) IDOPRN, IDOPLT should be set to 1 or 3)

IDOSUR: option for prints all vertical levels of the field arrays or just the values at the surface

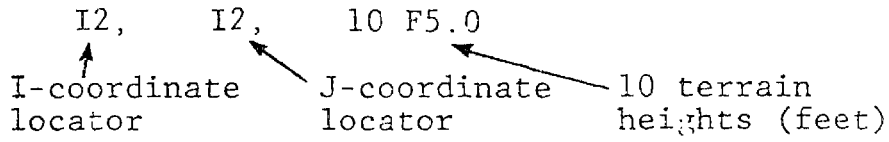
IDOSUR = 0 print all vertical levels plus the surface

IDOSUR = 1 print surface values only

4.3.5 Terrain Deck

Each card in the terrain deck holds consecutive x terrain heights (in feet) and is self-identified by having x and y cell location values. If an entire record contains zero heights for each location, it is not required. A record with a value of I = -1 is required to terminate the terrain deck.

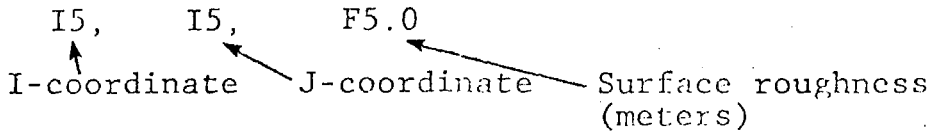
Each terrain record holds up to 10 distinct elevations. The terrain record format is diagrammed below:



The I-coordinate locator value is the I-coordinate of the 1st terrain value on the record and can have only the following values: 1, 11, 21, 31. The values on the card thus correspond to locations at (I, J), (I+2, J), ... (I+9, J). The J-coordinate locator has the values 1, 2, 3... NY.

4.3.6 Surface Roughness Deck

The surface roughness deck contains two types of records. The first record, read as an I5 format, describes the number of surface roughness data records to follow. This information is stored in NUMSRD. The next NUMSRD records contain data on the location and value of surface roughness. The format is as follows:

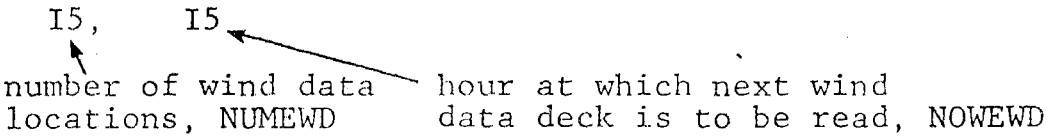


This data is only required if the Myrup/Ranzieri diffusivity model is desired. If no surface roughness data is needed, set NUMSRD = 0 to terminate the surface roughness deck.

The following data decks are required each hour except as noted.

4.3.7 Wind Data Deck

The first record of the wind data deck describes the number of wind data sites (stored as NUMEWD) and the hour at which the next wind data deck is to be read (stored as NOWEWD). This procedure allows the user to use the same wind data for multiple hours without rereading the same data deck each hour. If NOWEWD is set to 0, the wind data deck must be read in the next hour. If (at hour 2) NUMEWD = 5, the data deck read in at hour two will be used to calculate the wind field for hours 2, 3, and 4; at hour 5, a new wind data deck must be entered. The format of the data deck specification record is as follows:



For each wind data site, at least two records are required. The first record specifies the location of the wind data site and the confidence value (from 0.0 - 1.0) that the user places in the data (a value of 1.0 will force the wind field to agree with input value at the site, while a value of 0.0 will initialize the wind field using the input data but will allow the wind field to adjust itself without further regard to the input data). Valid, reliable hour average wind data is usually weighted as 1.0, while instantaneous pibal data is usually weighted as 0.1.

Note: The number of terrain cells at any location I, J can be determined by:

$$\text{IHT (I,J)} = \text{Integer portion of } \left[\left(\frac{\text{HT(I,J)} - \text{HTMIN}}{3.2808 \cdot \text{DZ}}\right) + .5\right]$$

where

IHT (I,J)	is the number of terrain cells at I,J
HT (I,J)	is the height in feet at I,J
HTMIN	is the minimum value in the HT array
DZ	is the vertical cell size in meters

At least one wind data location is required and a maximum of 50 data locations are permitted.

4.3.8 Stability Data Deck

The first record of the stability data deck, like the first record of the wind data deck, describes the number of stability data sites (stored as NUMESD) and the hour at which the next set of stability data is to be read (stored as NOWESD). The format is the same as for the wind data record:

```
I5,    I5
```

number of stability data locations, NUMESD

hour at which the next stability data is to be read, NOWESD

For each stability data location, at least two records are required. the first record contains the location of the stability data:

```
I5,  I5
```

I-location J-location

The next record contains up to 16 values of atmospheric stability. If NZ >16, another record containing stability data for K = 17, 18, 19, 20 is needed. The stability data is entered in the following format:

16 F5.0

where values of stability may be specified as:

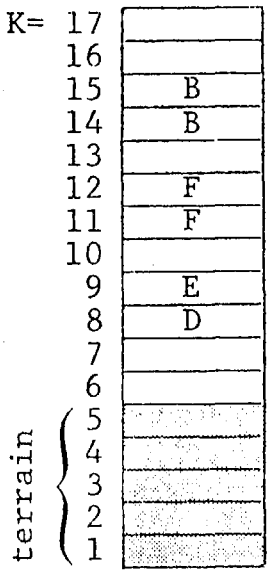
0	inside terrain
1.0 - 1.5	Pasquill stability class A
1.5 - 2.5	Pasquill stability class B
2.5 - 3.5	Pasquill stability class C
3.5 - 4.5	Pasquill stability class D
4.5 - 5.5	Pasquill stability class E
5.5 - 6.5	Pasquill stability class F
6.5 - 7.0	Pasquill stability class G

Table 5 may be used as a guide for converting temperature sounding data to stability. Unlike the wind data, the stability data is not entered relative to local ground-level. The code does not fill in blanks in the vertical; thus, the user must enter exactly NZ values of stability (assigning zero to cells inside terrain and assigning stabilities to cells which actually may not have had a datum value).

Table 5. Classification of Atmospheric Stability According to AEC Safety Guide 23.

Stability Classification	Pasquill Categories	Temperature Change With Height (°C/100m)
Extremely unstable	A	< -1.9
Moderately unstable	B	-1.9 to -1.7
Slightly unstable	C	-1.7 to -1.5
Neutral	D	-1.5 to -0.5
Slightly stable	E	-0.5 to 1.5
Moderately stable	F	1.5 to 4.0
Extremely stable	G	> 4.0

Example:



NZ = 17

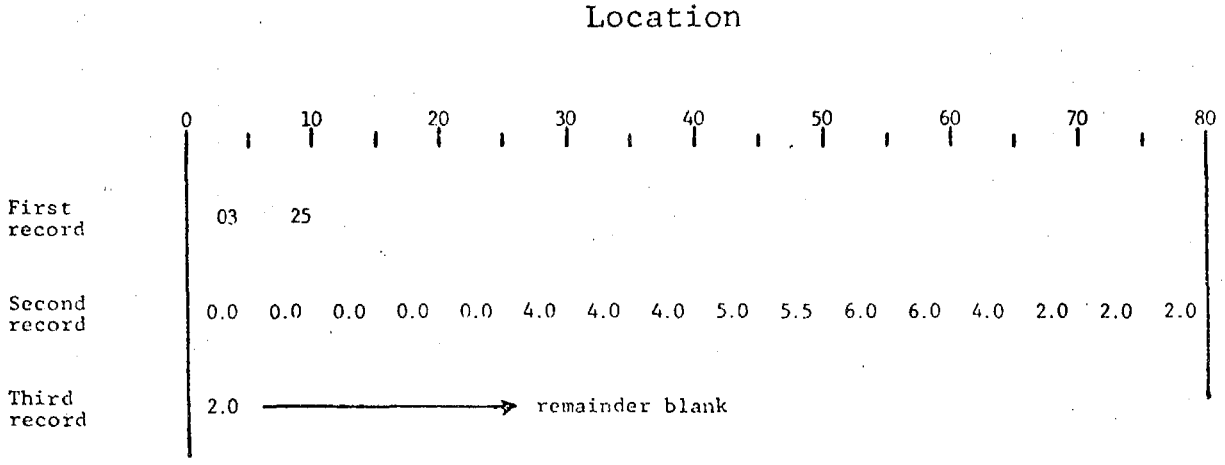
Location I = 3, J = 25

Set B = 2.0, F = 6.0, E = 5.0, D = 4.0

Extra values for needed cells 17, 16, 13, 10, 7, 6

Choose ⟶ 2.0, 2.0, 4.0, 5.5, 4.0, 4.0 respectively

The input records for this site would be:



At least one stability datum must be specified for every K-level; a maximum of 50 stability data sites are allowed.

4.3.9 Point Source Deck

If IDOCEM = 0, the point source data deck is not required. The first record of the point source deck, like the first record of the wind data deck, describes the number of point sources (stored as NUMEPS), and the hour at which the next point source data is to be read (stored as NOWEPS). If only one set of point source data is desired, set NOWEPS to a number greater than the number of hours to be simulated (NUMHRS). The format is the same as the wind data record, i.e.,

```
I5,   I5
 ↗     ↖
NUMEPS  NOWEPS
```

If no point sources are needed for a particular hour, set NUMEPS = 0 and omit the following records.

For each point source, two records are required. The first record contains information on the stack and its operating conditions. The format and the associated variables are as follows:

```
I5,   I5,   F5.0,   F5.0,   F5.0,   F5.0,   F5.0,   F5.0
 ↑     ↑     ↑       ↑       ↑       ↑       ↑       ↑
IPS   JPS   HPS     TPS     VPS     DPS     SPS     UDH
```

Stack variable definitions

IPS: The I-coordinate of the stack
JPS: The J-coordinate of the stack
HPS: Stack height in meters (relative to local terrain)
TPS: Temperature of the plume in ^{o}C
VPS: The stack volume flow in m^3/sec
DPS: The inside diameter at the top of the stack in meters
SPS: The exit plume velocity in meters/sec
UDH: A specified plume rise parameter

If

IDOPLM = 7 Δh = UDH/S UDH in m^2/sec

If

IDOPLM = 8 Δh = UDH UDH in meters

where

Δh is the plume rise (meters)

S is the wind speed at the top of the stack m/sec

If VPS is specified, DPS and SPS are not required, or vise versa. If UDH is specified, then TPS, VPS, DPS and SPS are not required.

The second record contains information on the point source emissions. The input on this record varies with the choice of IDOCEM. However, all data are read into EPST in a 16F5.0 format and are in units of grams/second. They are specified as follows:

	IDOCEM = 1	IDOCEM = 3	IDOCEM = 6	IDOCEM = 15
EPST (1)	tracer	tracer	tracer	tracer
EPST (2)		SO_2	NO_2	NO_2
EPST (3)		SO_4	NO	NO
EPST (4)			O_3	O_3
EPST (5)			HC (reactive)	HC1 (olefins)
EPST (6)			HNO_2	HC2 (aromatics)
EPST (7)				HC3 (parafins)
EPST (8)				HC4 (aldehydes)
EPST (9)				N_2O_5
EPST (10)				HNO_3
EPST (11)				HNO_2
EPST (12)				HO_2
EPST (13)				H_2O_2
EPST (14)				ROO
EPST (15)				RCOO

A maximum of 50 point sources may be specified.

4.3.10 Area Source Deck

If IDOCEM = 0, area source deck is not required.

The first record of the area source deck describes the number of area sources (stored as NUMASD) and the hour at which the next area source deck is to be read (stored as NOWASD). The format is the same as for the point source data:

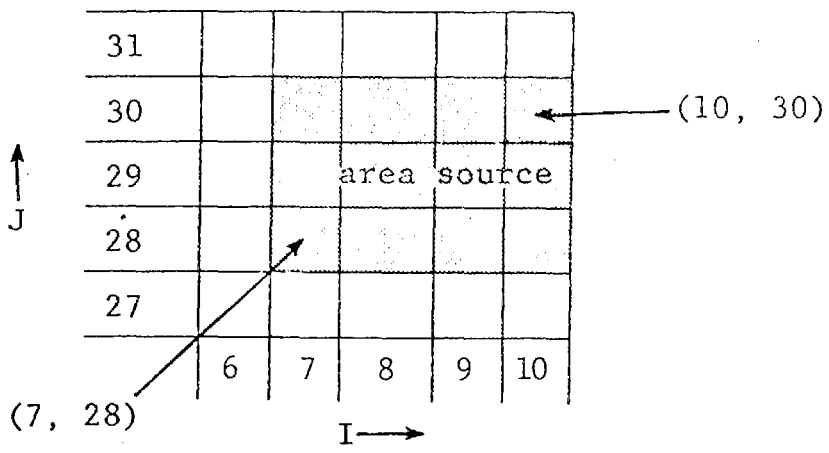
```
I5,   I5
 ↗     ↖
NUMASD  NOWASD
```

If no area sources are needed for a particular hour, set NUMASD = 0 and omit the following records. If only one set of area source data is desired for the entire problem set NOWASD > NUMHRS.

For each area source, two records are required. The first record contains information on the location of the area source. Each area source is defined as a rectangle whose sides are an integral number of DX and DY. The locations of the lower-left corner and the upper-right corner of the area source are required to specify the area source. The format for this record is as follows:

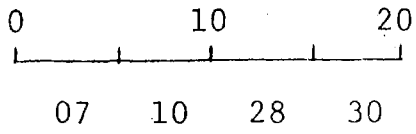
```
I5,   I5,   I5,   I5
 ↗     ↑     ↑     ↖
ILAS  IHAS  JLAS  JHAS
```

Example:



In this example, ILAS = 7, IHAS = 10, JLAS = 28, JHAS = 30.

The record would look like this:



If only one cell is required to specify an area source, set ILAS = IHAS, JLAS = JHAS. However, all data must be entered in this record. The second record contains information on the area source emissions. The format of this record is exactly the same as the point source emissions record. (Refer to section 4.13.13 for further information.)

The emissions required for the area source deck are in grams per second per grid cell. Thus, if the emissions for the entire area source is E' g/sec, the emissions per grid cell, ε g/sec/grid cell, equal E' /((IHAS-ILAS + 1)·(JHAS-JLAS + 1)). The variable ε is required as input in this record.

A maximum of 50 area sources may be specified.

4.3.11 Background Concentration Deck

The background concentration deck allows the user to specify the spatial distribution of pollutants. Those cells not affected by point or area sources (defined as cells whose tracer concentrations is less than 0.001 $\mu g/m^3$) are assigned concentrations based on a weighted, $1/r^2$, interpolation of background concentration values at the particular vertical level. Thus, the user must specify the vertical profile for all pollutants at each site. If IDOCEM = 0, the background concentration deck is not required.

The first record of the background concentration deck describes the number of background sites (stored as NUMBCP) and the hour at which the next background concentration deck is to be read (stored as NOWBCP). The format is the same for the point source data:

```
I5,   I5
NUMBCP  NOWBCP
```

If no background data is needed, set NUMBCP and omit the following records. If only one set of data is needed for the entire problem, set NOWBCP > NUMHRS. If, for example, no data is needed for the entire problem (e.g., if IDOCEM = 1, tracer only), set NUMBCP = 0 and NOWBCP = NUMHRS + 1.

For each background concentration data point, NZ + 1 records are required. The first record describes the coordinate location:

```
I5,   I5
IBC   JBC
```

where

IBC is the I-location of the background data
JBC is the J-location of the background data

The next NZ records describe the background concentrations of the reactive pollutants for each level starting at K = 1 and continuing to K = NZ. If, for example, levels K = 1 to K = 6 are below the surface, six blank cards must be inserted to account for levels K = 1 to K = 6. Every level must be specified. The input on these records varies with the selection of IDOCEM. However, all data are read into EBC in a 14F5.0 format and are in units of ppm. They are specified as follows:

	IDOCEM = 3	IDOCEM = 6	IDOCEM = 15
EBC (1)	SO_2	NO_2	NO_2
EBC (2)	SO_4	NO	NO
EBC (3)		O_3	O_3
EBC (4)		HC (reactive)	HC1
EBC (5)		HNO_2	HC2
EBC (6)			HC3
EBC (7)			HC4
EBC (8)			N_2O_5
EBC (9)			HNO_3
EBC (10)			HO_2
EBC (11)			HO_2
EBC (12)			H_2O_2
EBC (13)			ROO
EBC (14)			RCOO
EBC (15)			

If IDOCEM = 3, 6 or 15, at least one background concentration data must be specified for every K level; a maximum of 50 background concentration data sites may be specified.

4.3.12 Global Parameters Data

The global parameter data record specifies spatially invariant data required for conversion of emission g/sec to emissions ppm (the calculation of plume rise and parameters needed for photochemical calculations). If IDOCEM = 0, this record is not required. Otherwide, this record is required each hour and concludes the hour input unit. The format of this record is as follows:

F5.0,	F5.0,	F5.0,	F5.0,	F5.0
TGRND	SOLAR	PRESR	AMBCO	AMHZO

With the following global parameter definitions:

TGRND: air temperature at the surface ^{o}C (specify 20° as a default value)

SOLAR: ambient insolation in watts/m^2 (needed for photochemical simulations)

PRESR: ambient atmospheric pressure in millibars (specify 1000. as a default value)

AMBCO: ambient carbon monoxide in ppm (required for EPA photochemistry, IDOCEM = 15)

AMHZO: ambient water vapor concentration in ppm (required for EPA photochemistry, IDOCEM = 15)

4.4 PROGRAM INPUT SUMMARY

Table 6 provides a summary of program input.

Table 6. Summary of Input Data File.

DECK TYPE	VARIABLE	FORMAT
TITLE	TITLE IMPACT RUN	20A4
&GRIDIT	DX, DY, DZ, NX, NY, NZ	NAMELIST
&OPTION	IDOWND = 1 WEST IDOCEM = 0 WIND ONLY, = 1 TRACER = 3 SULFATE, = 6 GRC, = 15 EPA IDOPLM = 1 BRIGGS 69, = 2 BRIGGS 74, = 3 TVA, = 7 UΔH, = 8ΔH IDODIF = 1 M/R MODEL, = 3 DEPICT MODEL	NAMELIST
&OUTPUT	IDOCAL = 1 IDOPLT, IDOPRN, NUMBER OF HOURS BETWEEN PLOTS, EDITS IDOSUR = 0 ALL LEVELS AND SURFACE, = 1 SURFACE ONLY HRSAVG NUMBER OF HOURS TO AVERAGE SURFACE CONCENTRATIONS NUMHRS HOURS OF SIMULATION	NAMELIST
TERRAIN	I, J HT(I, J), ... HT (I +9, J) 'HT IN FEET' I = -1 TO END DECK	2I5, 10F 5.0
SURFACE ROUGHNESS	NUMSRD #SURFACE ROUGHNESS DATA POINTS I, J, ZO } REPEAT NUMSRD TIMES (ZO IN METERS)	I5 2I5, F 5.0
	HOURLY DATA — REPEAT EACH HOUR	
WIND	NUMEWD, NOWEWD I, J, WT (WS (K), WD (K), K=1, NZ) } REPEAT NUMESD TIMES SPEED, DIRECTION	2I5 2I5, F 5.0 16F 5.0
STABILITY	NUMESD, NOWESD I, J (STAB (I, J, K), K=1, NZ) } REPEAT NUMESD TIMES	2I5 2I5 16F 5.0
POINT SOURCE	NUMEPS, NOWEPS IPS, JPS, HPS, TPS, VPS, DPS, SPS, MDH — REPEAT NUMEPS TIMES (EPST (N), N=1, NS) EMISSIONS, G/SEC — REPEAT NUMEPS TIMES	2I5 2I5, 6F 5.0 15F 5.0
AREA SOURCE	NUMASD, NOWASD ILAS, IHAS, JLAS, JHAS } REPEAT NUMASD TIMES (EAST (N), N=1, NS) EMISSIONS G/SEC } REPEAT NUMASD TIMES	2I5 4I5 15F 5.0
BACKGROUND CONCENTRATION	NUMBCP, NOWBCP } REPEAT NUMBCP TIMES IBC, JBC } REPEAT NUMBCP TIMES ((EBC (N,K), N=2, NS), K=1, NZ) } REPEAT NUMBCP TIMES CONCENTRATION PPM	2I5 2I5 14F 5.0
GLOBAL PARAMETER	TGRND, SOLAR, PRESR, AMBLO, AMHZO (20), (150 W/M^2), (1000 MB), (10 PPM), (20000 PPM)	5F 5.0

5. CAVEATS

This section provides some helpful points on assembling the data and interpreting the output.

5.1 STABILITY ASSIGNMENT

Since the stability profile (stored in STAB) alters the computed wind field it is import to assign the stability layer by layer such that the intended profile is effected. The point to remember is that the stability of a given layer is assigned to the top interface of that layer. For example, if it is desired to simulate an atmosphere with the third layer stable and all the other layers unstable, the following assignment must be followed:

physically	assignment
A	A
A	A
A	A
A	A
A	A
E	E
A	E
A	A

thus STAB (2) = 5
and STAB (3) = 5

5.2 GRID SIZE

If IMPACT is used to evaluate the effects on air quality due to point sources, the grid size (DX, DY) should be equal to or less than the plume width at the surface concentration maximum. If DX or DY is too large, the maximum surface concentration will be smoothed and lower concentration values will be predicted. Typical zone sizes are from 500 to 1000 meters for DX, DY and 25 to 100 meters for DZ.

5.3 NUMBER OF SPECIFIED WIND SITES

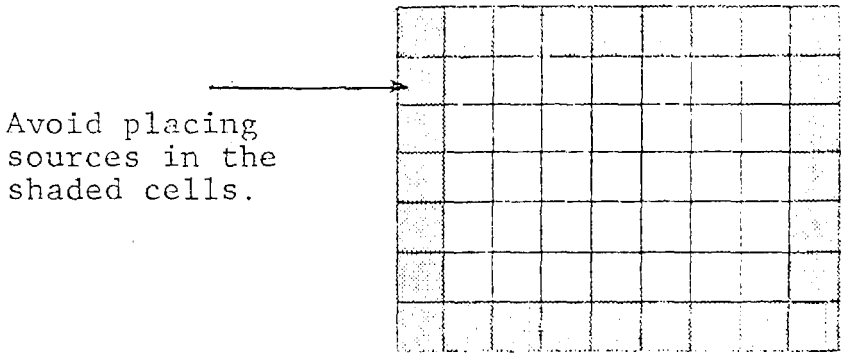
If an excessive number of wind sites are used, the assignment of high confidence levels to each site will result in an unrealistic wind field if the data is not compatable. A rule of thumb for determining the maximum number of high confidence level wind sites is N = (NX·NY) divided by 40⟶/40. If the number of wind sites exceeds N, reduce the confidence values assigned to the wind data.

5.4 MYRUP/RANZIERI DIFFUSIVITY MODEL

When using the Myrup/Ranzieri Model (IDODIF = 1), the user should take care that an inversion base and top are defined everywhere in the grid. That is, the stability values go from less than 4.5 at the surface to greater than 4.5 and then to less than 4.5 again. Otherwise, the model may calculate large vertical diffusivities (limited to 1000 m^2/sec) even under stable conditions when DZ·NZ is greater than 500 to 1000 meters. The advection/diffusion time step will be limited in these circumstances to approximately $\Delta t = 0.0008\ (DZ)^2$; if DZ is equal to 100 meters, then Δt equal 8 seconds. A time step of 8 seconds requires 450 advection/diffusion cycles per hour which will result in long run times for multiple-species multiple-hour simulations.

5.5 LOCATION OF POINT AND AREA SOURCES

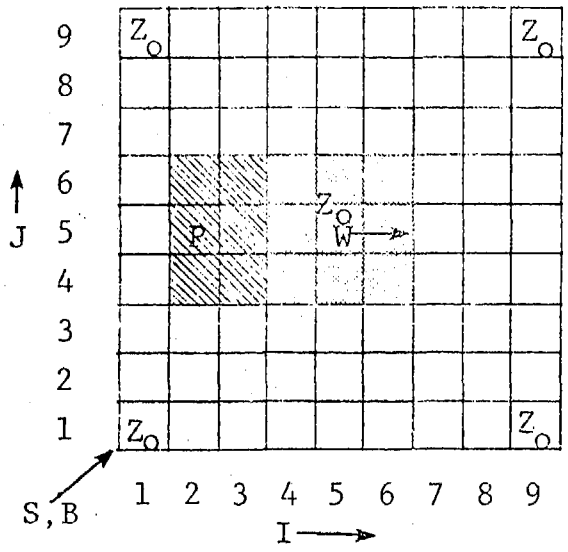
Due to the boundary conditions specified for the second order advection/diffusion algorithm, placing point or area sources in cells at the edge of the computational domain will result in an over prediction of pollutant concentrations. The user should take care that all point and area sources are at least one cell removed from the boundary.



6.0 EXAMPLE PROBLEM

A simplified exemplary problem designed to demonstrate several of the features and options available in the IMPACT code is described below. Section 6.1 illustrates the input file and section 6.2 is the program output.

The problem illustrated below is a grid of dimensions NX = NY = 9, NZ = 7; DX = 750, DY = 500, DZ = 100. The shaded area indicates the non-zero terrain (height = 1000 feet). Five surface roughness data are specified (Z_o), although they are not required since IDODIF = 3 (DEPICT diffusivity).



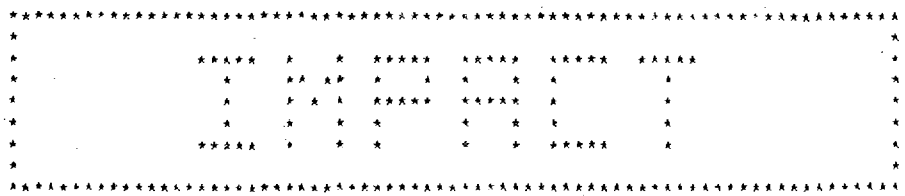
The problem is to be run for 2 hours, with wind and stability data specified (wind at w, stability at s) each hour. Sulfate chemistry is selected (IDOCEM = 3) and there is simulation of both a point source, P, with a user-specified Δh and emission equal to 10 g/sec tracer, 500 g/sec SO_2, and no SO_4 and an area source, indicated by the cross hatched area, with emissions per grid cell equal to 2 g/sec tracer and 270 g/sec SO_2. Background concentrations (B) are set to 0.0 for all levels and all species. The wind direction remains constant at 270° for both hours, while the wind speed changes from 3.0 m/sec to 1.5 m/sec. The stability profile is unstable to neutral to stable the first hour, changing to completely stable the second hour.

6.1 EXAMPLE PROBLEM INPUT FILE

```
                    I M P A C T   T E S T   P R O B L E M
&GRIDIT  DX=750,DY=500.,DZ=100,0,NX=9,NY=9,NZ=7,  &END
&OPTION  IDOWND=1,IDOCEM=3,IDOPLM=8,IDODIF=3,          &END
&OUTPUT  IDOPLT=1,IDOCAL=0,IDOPRN=1,HRSAVG=2,NUMHRS=2,IDOSUR=1, &END
   1     6   0.    0.    0.1000.1000.1000.    0.    0.    0.
   1     5   0.    0.    0.1000.1000.1000.    0.    0.    0.
   1     4   0.    0.    0.1000.1000.1000.    0.    0.    0.
  -1
   5
   1     1   .1
   1     9   .1
   9     1   .1
   9     9   .1
   5     5   1.
   1     2          HOUR 1
   5     5   .8
  3. 270.
   1     2
   1     1
  2.    2.    2.    3.    4.    5.    6.
   1     3
   2     5 100.    0.    0.    0.    0. 120.
 10. 500.    0.
   1     3
   2     3     4     6
  2. 270.    0.
   1     3
   1     1
  0.    0.    0.
  0.    0.    0.
  0.    0.    0.
  0.    0.    0.
  0.    0.    0.
  0.    0.    0.
  0.    0.    0.
 20.    0.1000.    0.    0.
   1     3          HOUR 2
   5     5   1.
 1.5 270.
   1     3
   1     1
  6.    6.    6.    6.    6.    6.    6.
 25.    0.1000.    0.    0.
```

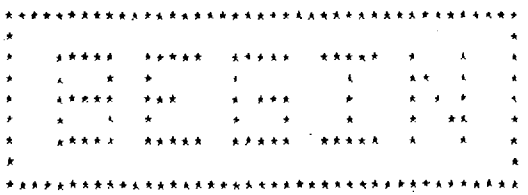
6.2 EXAMPLE PROBLEM OUTPUT

```
                                    I M P A C T   T E S T   P R O B L E M
$GRIDIT
 DX=   750.0000    ,  DY=   500.0000    ,  DZ=   100.0000    ,  NX=            9,  NY=            9,  NZ=            7,
$
$OPTION
 IDOWND=          1,  IDOCEM=          3,  IDOPLM=          8,  IDODIF=          3, $
$OUTPUT
 IDOPLT=          1,  IDOCAL=          0,  IDOPRN=          1,  HRSAVG=   2.000000    ,  NUMHRS=          2,
 IDOSUR=          1, $
```



DIRECT QUESTIONS CONCERNING THIS CODE TO:

ALLAN FABRICK
RALPH SKLAREW
JAMES TAFT
JOHN WILSON
(213) 889-0514



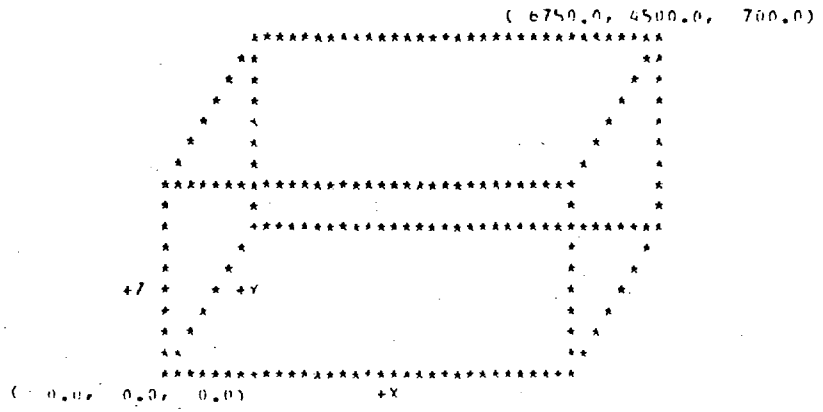
```
*********************************************
*                                           *
*        INITIAL STATE OF THE SYSTEM        *
*                                           *
*********************************************
```

I M P A C T T E S T P R O B L E M

GRID DEFINITION

```
     THERE ARE   9 CELLS IN THE X DIRECTION WITH A DELTA X OF   750.0M YIELDING A TOTAL EXTENT OF  6750.0M
     THERE ARE   9 CELLS IN THE Y DIRECTION WITH A DELTA Y OF   500.0M YIELDING A TOTAL EXTENT OF  4500.0M
     THERE ARE   7 CELLS IN THE Z DIRECTION WITH A DELTA Z OF   100.0M YIELDING A TOTAL EXTENT OF   700.0M
```

GRID ORIENTATION



REQUESTED MODES OF OPERATION

WIND FIELD

THE WIND FIELD IS TO BE GENERATED BY WEST

TURBULENCE

DIFFUSIVITIES TO BE DEVELOPED FROM DEPICT METHOD

PLUME RISE

PLUME RISE GIVEN BY USER IN 'DH' FORM

CHEMISTRY
---
3 SPECIES CHEMISTRY HAS BEEN REQUESTED

TIMING PARAMETERS

RUN TIME

A 2 HOUR SIMULATION HAS BEEN REQUESTED.

OUTPUT OPTIONS

PRINTER PLOTS HAVE BEEN REQUESTED EVERY 1 HOURS
PRINTER EDITS HAVE BEEN REQUESTED EVERY 1 HOURS
SURFACE CONCENTRATIONS ARE 2 HOUR AVERAGES

INPUT TERRAIN DATA

I	J	ELEVATIONS (FT)								
1	6	0.	0.	0.	1000.	1000.	1000.	0.	0.	0.
1	5	0.	0.	0.	1000.	1000.	1000.	0.	0.	0.
1	4	0.	0.	0.	1000.	1000.	1000.	0.	0.	0.

REFERENCE HEIGHT AT BOTTOM OF GRID (M) = 0.00

SURFACE ROUGHNESS DATA

N	I	J	Z0 (M)
1	1	1	0.10
2	1	9	0.10
3	9	1	0.10
4	9	9	0.10
5	5	5	1.00

TERRAIN HEIGHT CONTOURS (M)

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	0.00000E+00 -	1.52402E+01
	1.52402E+01 -	3.04804E+01
1	3.04804E+01 -	4.57206E+01
	4.57206E+01 -	6.09608E+01
2	6.09608E+01 -	7.62010E+01
	7.62010E+01 -	9.14412E+01
3	9.14412E+01 -	1.06681E+02
	1.06681E+02 -	1.21922E+02
4	1.21922E+02 -	1.37162E+02
	1.37162E+02 -	1.52402E+02
5	1.52402E+02 -	1.67642E+02
	1.67642E+02 -	1.82882E+02
6	1.82882E+02 -	1.98123E+02
	1.98123E+02 -	2.13363E+02
7	2.13363E+02 -	2.28603E+02
	2.28603E+02 -	2.43843E+02
8	2.43843E+02 -	2.59083E+02
	2.59083E+02 -	2.74323E+02
9	2.74323E+02 -	2.89564E+02
	2.89564E+02 -	3.04804E+02

MAXIMUM VALUE= 3.04804E+02 MINIMUM VALUE= 0.00000E+00

TERRAIN HEIGHT PRINT (M)

MULTIPLIER= 1.00000E+01

I=		1	2	3	4	5	6	7	8	9
J=	9	0	0	0	0	0	0	0	0	0
J=	8	0	0	0	0	0	0	0	0	0
J=	7	0	0	0	0	0	0	0	0	0
J=	6	0	0	0	30	30	30	0	0	0
J=	5	0	0	0	30	30	30	0	0	0
J=	4	0	0	0	30	30	30	0	0	0
J=	3	0	0	0	0	0	0	0	0	0
J=	2	0	0	0	0	0	0	0	0	0
J=	1	0	0	0	0	0	0	0	0	0

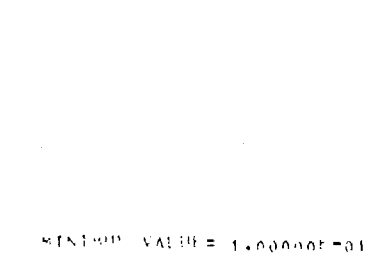
CELLULARIZED TERRAIN HEIGHT

I=		1	2	3	4	5	6	7	8	9
J=	9	0	0	0	0	0	0	0	0	0
J=	8	0	0	0	0	0	0	0	0	0
J=	7	0	0	0	0	0	0	0	0	0
J=	6	0	0	0	3	3	3	0	0	0
J=	5	0	0	0	3	3	3	0	0	0
J=	4	0	0	0	3	3	3	0	0	0
J=	3	0	0	0	0	0	0	0	0	0
J=	2	0	0	0	0	0	0	0	0	0
J=	1	0	0	0	0	0	0	0	0	0

SURFACE ROUGHNESS CONTOURS (M)

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
0	1.000000E-01 -	1.450000E-01
	1.450000E-01 -	1.900000E-01
1	1.900000E-01 -	2.350000E-01
	2.350000E-01 -	2.800000E-01
2	2.800000E-01 -	3.250000E-01
	3.250000E-01 -	3.700000E-01
3	3.700000E-01 -	4.150000E-01
	4.150000E-01 -	4.600000E-01
4	4.600000E-01 -	5.050000E-01
	5.050000E-01 -	5.500000E-01
5	5.500000E-01 -	5.950000E-01
	5.950000E-01 -	6.400000E-01
6	6.400000E-01 -	6.850000E-01
	6.850000E-01 -	7.300000E-01
7	7.300000E-01 -	7.750000E-01
	7.750000E-01 -	8.200000E-01
8	8.200000E-01 -	8.650000E-01
	8.650000E-01 -	9.100000E-01
9	9.100000E-01 -	9.550000E-01
	9.550000E-01 -	1.000000E+00



SURFACE ROUGHNESS PRIME (-)

MULTIPLIER= 1.000000E-01

I=		1	2	3	4	5	6	7	8	9
J=	9	1	1	3	3	5	4	3	1	1
J=	8	1	2	4	5	6	5	4	2	1
J=	7	2	3	5	7	8	7	5	3	2
J=	6	2	3	5	8	9	8	5	3	2
J=	5	3	4	6	9	10	9	6	4	3
J=	4	2	3	5	8	9	8	5	3	2
J=	3	2	3	5	7	8	7	5	3	2
J=	2	1	2	4	5	6	5	4	2	1
J=	1	1	1	3	4	5	4	3	1	1

T H P A C T T E S T P R O B L E M

```
*****************************************                                  *****************************************
*                                       *                                  *                                       *
*    SUMMARY OF CURRENT YET DATA        *                                  * CURRENT SIMULATION TIME  1.0 HRS     *
*                                       *                                  *                                       *
*****************************************                                  *****************************************
```

ELEVATED WINDS

N	T	J	CONFIDENCE
1	5	5	0.800

K	WIND SPEED (M/S)	WIND DIRECTION (DEG)
1	3.0	270.0
2	0.0	0.0
3	0.0	0.0
4	0.0	0.0
5	0.0	0.0
6	0.0	0.0
7	0.0	0.0

ELEVATED STABILITY DATA

N	T	J	K	STABILITY
1	1	1		
			1	2.0
			2	2.0
			3	2.0
			4	3.0
			5	4.0
			6	5.0
			7	6.0

SUMMARY OF CURRENT EMISSIONS DATA

CURRENT SIMULATION TIME : 1.0 HRS

POINT SOURCES (GM/S)

N	I	J	EMISSIONS	STACK HEIGHT (M)	STACK TEMP (C)	FLOW RATE (M3/S)	STACK DIAM (M)	EXIT VELOC (M/S)	PLM RISE (M)
1	2	5		100.0	0.0	0.0	0.0	0.0	125.0
			SF6 10.0						
			SO2 500.0						
			SO4 0.0						

AREA SOURCES (GM/S)

N	IL	IH	JL	JH	SF6	SO2	SO4
1	2	3	4	6	2.0	270.0	0.0

BACKGROUND CONCENTRATION PROFILES (PPM)

N	I	J	K	SO2	SO4
1	1	1	1	0.00	0.00
			2	0.00	0.00
			3	0.00	0.00
			4	0.00	0.00
			5	0.00	0.00
			6	0.00	0.00
			7	0.00	0.00

GLOBAL ATMOSPHERIC PARAMETERS

GROUND TEMPERATURE = 2.00000E+01 (DEG C)
SOLAR INSOLATION = 0.00000E+00 (W/M**2)
SURFACE PRESSURE = 1.00000E+05 (MB)
AMBIENT CO2 = 0.00000E+00 (PPM)
AMBIENT MOISTURE = 0.00000E+00 (PPM)

BOUNDARY FLUX ADJUSTMENT

FLUX IN = 1.7491E+07
FLUX OUT = 1.7491E+07
FACTOR A = 1.0000E+00

WIND FIELD ADJUSTMENT

MAXIMUM RESIDUAL DIVERGENCE = 2.4697E-05 AT CELL I = 6 J = 5 K = 6
CELL VELOCITIES I = 5.2248E+00 I+1 = 7.3047E+00 J = 2.0548E+00 J+1 = -2.0538E+00 K = -6.9852E-01 K+1 = -1.5165E-01
PERCENT ERROR IN VELOCITY U = 3.6485E-02% V = 1.9055E-01% W = 1.2877E-02%

POINT SOURCE PLUME RISE

N	I	J	K	PLUME RISE	STK HGT	TERRAIN HGT	WND SPEED	TEMP GRAD	STABILITY
1	2	5	3	120.000	100.200	0.000	0.000	0.000	0.000

POLLUTANT ADVECTION DIFFUSION TIME STEP

DT	STEPS/HR	X-DT	Y-DT	Z-DT	ALPHA
52.94	68	76.70	108.50	56.49	1.95

SURFACE PLOT OF U VELOCITY

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
0	0.00000E+00 -	1.71419E-01
	1.71419E-01 -	3.42837E-01
1	3.42837E-01 -	5.14256E-01
	5.14256E-01 -	6.85675E-01
2	6.85675E-01 -	8.57093E-01
	8.57093E-01 -	1.02851E+00
3	1.02851E+00 -	1.19993E+00
	1.19993E+00 -	1.37135E+00
4	1.37135E+00 -	1.54277E+00
	1.54277E+00 -	1.71419E+00
5	1.71419E+00 -	1.88561E+00
	1.88561E+00 -	2.05702E+00
6	2.05702E+00 -	2.22844E+00
	2.22844E+00 -	2.39986E+00
7	2.39986E+00 -	2.57128E+00
	2.57128E+00 -	2.74270E+00
8	2.74270E+00 -	2.91412E+00
	2.91412E+00 -	3.08554E+00
9	3.08554E+00 -	3.25695E+00
	3.25695E+00 -	3.42837E+00

SURFACE PLOT OF V VELOCITY

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
0	-6.81677E-01 -	-6.13509E-01
	-6.13509E-01 -	-5.45341E-01
1	-5.45341E-01 -	-4.77173E-01
	-4.77173E-01 -	-4.09005E-01
2	-4.09005E-01 -	-3.40837E-01
	-3.40837E-01 -	-2.72669E-01
3	-2.72669E-01 -	-2.04501E-01
	-2.04501E-01 -	-1.36333E-01
4	-1.36333E-01 -	-6.81652E-02
	-6.81652E-02 -	2.80142E-06
5	2.80142E-06 -	6.81708E-02
	6.81708E-02 -	1.36339E-01
6	1.36339E-01 -	2.04507E-01
	2.04507E-01 -	2.72675E-01
7	2.72675E-01 -	3.40843E-01
	3.40843E-01 -	4.09011E-01
8	4.09011E-01 -	4.77179E-01
	4.77179E-01 -	5.45347E-01
9	5.45347E-01 -	6.13515E-01

SURFACE PLOT OF STABILITY

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	2.00000E+00 -	2.05000E+00
	2.05000E+00 -	2.10000E+00
1	2.10000E+00 -	2.15000E+00
	2.15000E+00 -	2.20000E+00
2	2.20000E+00 -	2.25000E+00
	2.25000E+00 -	2.30000E+00
3	2.30000E+00 -	2.35000E+00
	2.35000E+00 -	2.40000E+00
4	2.40000E+00 -	2.45000E+00
	2.45000E+00 -	2.50000E+00
		**********
5	2.50000E+00 -	2.55000E+00
	2.55000E+00 -	2.60000E+00
6	2.60000E+00 -	2.65000E+00
	2.65000E+00 -	2.70000E+00
7	2.70000E+00 -	2.75000E+00
	2.75000E+00 -	2.80000E+00
8	2.80000E+00 -	2.85000E+00
	2.85000E+00 -	2.90000E+00
9	2.90000E+00 -	2.95000E+00
	2.95000E+00 -	3.00000E+00

MAXIMUM VALUE= 3.00000E+00 MINIMUM VALUE= 2.00000E+00

SURFACE PLOT OF X DIFFUSIVITY

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	0.00000E+00 -	1.20616E+00
	1.20616E+00 -	2.41233E+00
1	2.41233E+00 -	3.61849E+00
	3.61849E+00 -	4.82465E+00
2	4.82465E+00 -	6.03082E+00
	6.03082E+00 -	7.23698E+00
3	7.23698E+00 -	8.44314E+00
	8.44314E+00 -	9.64931E+00
4	9.64931E+00 -	1.08555E+01
	1.08555E+01 -	1.20616E+01
		**********
5	1.20616E+01 -	1.32678E+01
	1.32678E+01 -	1.44740E+01
6	1.44740E+01 -	1.56801E+01
	1.56801E+01 -	1.68863E+01
7	1.68863E+01 -	1.80925E+01
	1.80925E+01 -	1.92986E+01
8	1.92986E+01 -	2.05048E+01
	2.05048E+01 -	2.17109E+01
9	2.17109E+01 -	2.29171E+01

MAXIMUM VALUE= 2.41233E+01 MINIMUM VALUE= 0.00000E+00

2.29171E+01 - 2.41233E+01

SURFACE PLOT OF Y DIFFUSIVITY

CONTOUR LEVELS

PLOT CHAR	INTERVAL		
0	0.00000E+00	-	1.20390E+00
	1.20390E+00	-	2.40780E+00
1	2.40780E+00	-	3.61170E+00
	3.61170E+00	-	4.81560E+00
2	4.81560E+00	-	6.01950E+00
	6.01950E+00	-	7.22340E+00
3	7.22340E+00	-	8.42730E+00
	8.42730E+00	-	9.63120E+00
4	9.63120E+00	-	1.08351E+01
	1.08351E+01	-	1.20390E+01
5	1.20390E+01	-	1.32429E+01
	1.32429E+01	-	1.44468E+01
6	1.44468E+01	-	1.56507E+01
	1.56507E+01	-	1.68546E+01
7	1.68546E+01	-	1.80585E+01
	1.80585E+01	-	1.92624E+01
8	1.92624E+01	-	2.04663E+01
	2.04663E+01	-	2.16702E+01
9	2.16702E+01	-	2.28741E+01
	2.28741E+01	-	2.40780E+01

```
********************
*                  *
*                  *
*                  *
*  99770000007799  *
*  99445555774499  *
*  99445555774499  *
*  99777777887799  *
*                  *
*                  *
*                  *
********************
```

MAXIMUM VALUE= 2.40780E+01 MINIMUM VALUE= 0.00000E+00

CONCENTRATION AT TIME 1 HOURS AFTER START OF SIMULATION

SURFACE PLOT OF TRACER UG/M**3

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	0.00000E+00 -	1.58802E+00
	1.58802E+00 -	3.17604E+00
1	3.17604E+00 -	4.76405E+00
	4.76405E+00 -	6.35207E+00
2	6.35207E+00 -	7.94009E+00
	7.94009E+00 -	9.52811E+00
3	9.52811E+00 -	1.11161E+01
	1.11161E+01 -	1.27041E+01
4	1.27041E+01 -	1.42922E+01
	1.42922E+01 -	1.58802E+01
5	1.58802E+01 -	1.74682E+01
	1.74682E+01 -	1.90562E+01
6	1.90562E+01 -	2.06442E+01
	2.06442E+01 -	2.22323E+01
7	2.22323E+01 -	2.38203E+01
	2.38203E+01 -	2.54083E+01
8	2.54083E+01 -	2.69963E+01
	2.69963E+01 -	2.85843E+01
9	2.85843E+01 -	3.01723E+01
	3.01723E+01 -	3.17604E+01

MAXIMUM VALUE= 3.17603E+01 MINIMUM VALUE= 0.00000E+00

SURFACE PLOT OF SO_2 ppm

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	0.00000E+00 -	1.14443E-02
	1.14443E-02 -	2.28886E-02
1	2.28886E-02 -	3.43329E-02
	3.43329E-02 -	4.57772E-02
2	4.57772E-02 -	5.72215E-02
	5.72215E-02 -	6.86658E-02
3	6.86658E-02 -	8.01101E-02
	8.01101E-02 -	9.15544E-02
4	9.15544E-02 -	1.02999E-01
	1.02999E-01 -	1.14443E-01
5	1.14443E-01 -	1.25887E-01
	1.25887E-01 -	1.37332E-01
6	1.37332E-01 -	1.48776E-01
	1.48776E-01 -	1.60220E-01
7	1.60220E-01 -	1.71664E-01
	1.71664E-01 -	1.83109E-01

MAXIMUM VALUE= 2.28886E-01 MINIMUM VALUE= 0.00000E+00

8	1.931095E-01	-	1.945535E-01
	1.945535E-01	-	1.959975E-01
9	1.959975E-01	-	1.974415E-01
	1.974415E-01	-	1.988855E-01

SURFACE PLOT OF SO_4 ppm

PLOT CHAR	CONTOUR LEVELS INTERVAL		
			**********
0	0.000000E+00	-	3.054984E-04
	3.054984E-04	-	6.109968E-04
1	6.109968E-04	-	9.164952E-04
	9.164952E-04	-	1.221994E-03
2	1.221994E-03	-	1.527492E-03
	1.527492E-03	-	1.832991E-03
3	1.832991E-03	-	2.138489E-03
	2.138489E-03	-	2.443988E-03
4	2.443988E-03	-	2.749486E-03
	2.749486E-03	-	3.054984E-03
5	3.054984E-03	-	3.360483E-03
	3.360483E-03	-	3.665981E-03
6	3.665981E-03	-	3.971480E-03
	3.971480E-03	-	4.276978E-03
7	4.276978E-03	-	4.582477E-03
	4.582477E-03	-	4.887975E-03
8	4.887975E-03	-	5.193474E-03
	5.193474E-03	-	5.498972E-03
9	5.498972E-03	-	5.804471E-03
	5.804471E-03	-	6.109968E-03

MAXIMUM VALUE= 6.109968E-03 MINIMUM VALUE= 0.000000E+00

SURFACE PRINT OF U VELOCITY

MULTIPLIER= 1.000000E-01

I=		1	2	3	4	5	6	7	8	9	10
J=	9	30	30	30	30	30	30	30	30	30	30
J=	8	30	30	30	30	30	30	30	30	30	30
J=	7	30	30	29	31	30	30	31	29	30	30
J=	6	30	29	25	34	30	32	9	26	29	30
J=	5	30	29	24	34	30	32	8	25	29	30
J=	4	30	29	25	34	30	32	8	26	29	30
J=	3	30	30	29	31	30	30	31	29	30	30
J=	2	30	30	30	30	30	30	30	30	30	30
J=	1	30	30	30	30	30	30	30	30	30	30

SURFACE PRINT OF V VELOCITY

MULTIPLIER= 1.000000E-02

I=		1	2	3	4	5	6	7	8	9
J=	10	0	1	2	1	0	-1	-1	-1	
J=	9	1	2	4	1	0	-1	-2	-1	0
J=	8	1	4	16	2	0	-3	-13	-3	-1
J=	7	1	8	68	0	0	0	-58	-6	-1
J=	6	0	2	13	1	0	-3	-11	-2	0
J=	5	0	-2	-13	-1	0	3	11	2	0
J=	4	-1	-8	-65	-2	1	13	58	6	1
J=	3	-1	-4	-16	-2	0	3	15	3	1
J=	2	-1	-2	-4	-1	0	1	4	1	0
J=	1	0	-1	-2	-1	0	1	1	1	0

SURFACE PRINT OF STABILITY

MULTIPLIER= 1.000000E-01

I=		1	2	3	4	5	6	7	8	9
J=	9	20	20	20	20	20	20	20	20	20
J=	8	20	20	20	20	20	20	20	20	20
J=	7	20	20	20	20	20	20	20	20	20
J=	6	20	20	20	30	30	30	20	20	20
J=	5	20	20	20	30	30	30	20	20	20
J=	4	20	20	20	30	30	30	20	20	20
J=	3	20	20	20	20	20	20	20	20	20

J=	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
J=	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	[illegible]

SURFACE PRINT OF X DIFFUSIVITY

MULTIPLIER= 1.00000E+00

I=		1	2	3	4	5	6	7	8	9	10
J=	9	24	24	24	24	24	24	24	24	24	[illegible]
J=	8	24	24	24	24	24	24	24	24	24	24
J=	7	23	23	24	24	24	24	24	24	24	24
J=	6	23	23	16	17	17	15	[illegible]	16	23	[illegible]
J=	5	22	22	16	15	13	15	[illegible]	16	23	23
J=	4	23	23	[illegible]	15	13	15	[illegible]	16	23	23
J=	3	23	23	24	24	24	24	24	24	[illegible]	[illegible]
J=	2	24	24	24	24	24	24	24	24	[illegible]	24
J=	1	24	24	24	[illegible]	24	24	24	24	24	24

SURFACE PRINT OF Y DIFFUSIVITY

MULTIPLIER= 1.00000E+00

I=		1	2	3	4	5	6	7	8	9
J=	10	24	24	24	24	24	24	24	24	24
J=	9	24	24	24	24	24	24	24	24	24
J=	8	24	23	24	24	24	24	24	24	24
J=	7	24	23	17	0	0	0	17	23	24
J=	6	23	22	10	13	13	18	10	22	23
J=	5	23	22	10	13	13	18	10	22	23
J=	4	24	23	17	18	17	20	17	23	24
J=	3	24	23	24	24	24	24	24	24	24
J=	2	24	24	24	24	24	24	24	24	24
J=	1	24	24	24	24	24	24	24	24	24

CONCENTRATION AT TIME 1 HOURS AFTER START OF SIMULATION

SURFACE PRINT OF TRACE? UG/M**3

MULTIPLIER= 1.00000E+00

I=	1	2	3	4	5	6	7	8	9
J= 9	0	0	0	0	0	0	0	0	0
J= 8	0	0	0	0	0	0	0	0	0
J= 7	0	0	5	4	3	3	2	2	2
J= 6	0	4	32	5	5	5	2	3	3
J= 5	0	7	30	17	16	16	7	9	16
J= 4	0	4	32	5	5	5	2	3	3
J= 3	0	0	5	1	3	3	2	2	2
J= 2	0	0	0	0	0	0	0	0	0
J= 1	0	0	0	0	0	0	0	0	0

SURFACE PRINT OF SO_2 ppm

MULTIPLIER= 1.00000E-02

I=	1	2	3	4	5	6	7	8	9
J= 9	0	0	0	0	0	0	0	0	0
J= 8	0	0	0	0	0	0	0	0	0
J= 7	0	0	2	1	1	1	1	1	1
J= 6	0	1	11	3	3	3	1	2	2
J= 5	0	7	14	23	21	22	9	13	13
J= 4	0	1	11	3	3	3	1	2	2
J= 3	0	0	2	1	1	1	1	1	1
J= 2	0	0	0	0	0	0	0	0	0
J= 1	0	0	0	0	0	0	0	0	0

SURFACE PRINT OF SO_4 ppm

MULTIPLIER= 1.00000E-04

I=	1	2	3	4	5	6	7	8	9
J= 9	0	0	0	0	0	0	0	0	0
J= 8	0	0	0	0	0	0	0	0	0
J= 7	0	0	2	3	3	3	3	3	3
J= 6	0	0	12	6	8	11	4	6	10
J= 5	0	2	21	36	47	61	37	50	60

C M P A C T T E S T P R O B L E M

```
*****************************************                                  *****************************************
*                                       *                                  *                                       *
*     SUMMARY OF CURRENT LOT DATA       *                                  * CURRENT SIMULATION TIME  2.0 HRS    *
*                                       *                                  *                                       *
*****************************************                                  *****************************************
```

ELEVATED WINDS

N	I	J	CONFIDENCE	K	WIND SPEED (M/S)	WIND DIRECTION (DEG)
1	5	5	1.000	1	1.5	270.0
				2	0.0	0.0
				3	0.0	0.0
				4	0.0	0.0
				5	0.0	0.0
				6	0.0	0.0
				7	0.0	0.0

ELEVATED STABILITY DATA

N	I	J	K	STABILITY
1	5	5	1	5.0
			2	5.0
			3	5.0
			4	5.0
			5	5.0
			6	5.0
			7	5.0

GLOBAL ATMOSPHERIC PARAMETERS

```
GROUND TEMPERATURE  = 2.500000E+01 (DEG C)
SOLAR INSOLATION    = 0.000000E+00 (W/M**2)
SURFACE PRESSURE    = 1.000000E+03 (MB)
AMBIENT CO2         = 0.000000E+00 (PPM)
AMBIENT NOTSTORE    = 0.000000E+00 (PPM)
```

BOUNDARY FLUX ADJUSTMENT

FLUX IN = 1.1382E+07
FLUX OUT = 1.1382E+07
FACTOR A = 1.0000E+00

WIND FIELD ADJUSTMENT

MAXIMUM RESIDUAL DIVERGENCE = 4.4755E-05 AT CELL I = 6 J = 5 K = 1
CELL VELOCITIES I = 1.5856E+00 I+1 = 3.0499E+00 J = 4.8471E-01 J+1 = -4.8056E-01 K = 0.0000E+00 K+1 = -3.6226E-03
PERCENT ERROR IN VELOCITY U = 1.4758E-02% V = 1.5816E-01% W = 1.2698E-01%

POINT SOURCE PLUME RISE

N	I	J	K	PLUME RISE	STK HGT	TERRAIN HGT	WND SPEED	TEMP GRAD	BUOYANCY
1	2	5	3	120.00	100.000	0.000	0.000	0.000	0.00

POLLUTANT ADVECTION DIFFUSION TIME STEP

DT	STEPS/HR	X-DT	Y-DT	Z-DT	ALPHA
128.57	28	138.79	277.61	3953.22	0.05

SURFACE PLOT OF U VELOCITY

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	0.00000E+00 - 1.26788E-01	* 66666666 *
	1.26788E-01 - 2.53576E-01	*5555 55*
1	2.53576E-01 - 3.80364E-01	*55 55 55 *
	3.80364E-01 - 5.07152E-01	* 44339999 003344*
2	5.07152E-01 - 6.33940E-01	* 44339966600334*
	6.33940E-01 - 7.60728E-01	* 44339999 003344*
3	7.60728E-01 - 8.87516E-01	*55 55 55 *
	8.87516E-01 - 1.01430E+00	*5555 55*
4	1.01430E+00 - 1.14109E+00	* 66666666 *
	1.14109E+00 - 1.26788E+00	****** **********
5	1.26788E+00 - 1.39467E+00	MAXIMUM VALUE= 2.53576E+00 MINIMUM VALUE= 0.00000E+00
	1.39467E+00 - 1.52146E+00	
6	1.52146E+00 - 1.64824E+00	
	1.64824E+00 - 1.77503E+00	
7	1.77503E+00 - 1.90182E+00	
	1.90182E+00 - 2.02861E+00	
8	2.02861E+00 - 2.15540E+00	
	2.15540E+00 - 2.28218E+00	
9	2.28218E+00 - 2.40897E+00	
	2.40897E+00 - 2.53576E+00	

SURFACE PLOT OF V VELOCITY

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	-8.96735E-01 - -8.03928E-01	*55 66 44 44*
	-8.03928E-01 - -7.11121E-01	*5566 4433 44*
1	-7.11121E-01 - -6.18314E-01	*55667755 44223344*
	-6.18314E-01 - -5.25507E-01	*5566 00334*
2	-5.25507E-01 - -4.32701E-01	*55556666 223344 *
	-4.32701E-01 - -3.39894E-01	* 443333 77665555*
3	-3.39894E-01 - -2.47087E-01	*44330033 6655*
	-2.47087E-01 - -1.54280E-01	*44332244 55776655*
4	-1.54280E-01 - -6.14730E-02	*44 3344 6655*
	-6.14730E-02 - 3.13338E-02	*44 3344 66 55*
5	3.13338E-02 - 1.24141E-01	**********
	1.24141E-01 - 2.16948E-01	MAXIMUM VALUE= 6.59402E-01 MINIMUM VALUE=-8.96735E-01
6	2.16948E-01 - 3.09754E-01	
	3.09754E-01 - 4.02561E-01	
7	4.02561E-01 - 4.95368E-01	
	4.95368E-01 - 5.88175E-01	
8	5.88175E-01 - 6.80982E-01	
	6.80982E-01 - 7.73789E-01	
9	7.73789E-01 - 8.66596E-01	

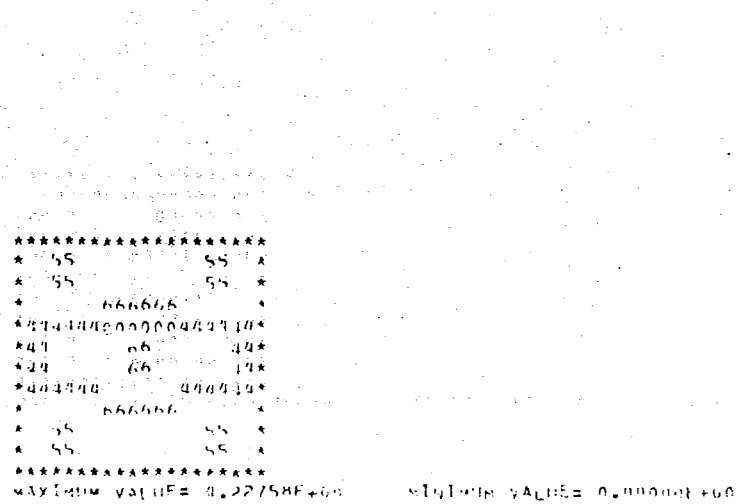
```
        [illegible]E-01 -  9.59403E-01


SURFACE PLOT OF STABILITY
-------------------------------
        CONTOUR LEVELS
        --------------
PLOT CHAR          INTERVAL
                                          ********************
   0       6.00000E+00 -  6.00000E+00     *    00  00    00  *
           6.00000E+00 -  6.00000E+00     *    00            *
   1       6.00000E+00 -  6.00000E+00     *          00      *
           6.00000E+00 -  6.00000E+00     *00                *
   2       6.00000E+00 -  6.00000E+00     *  0000            *
           6.00000E+00 -  6.00000E+00     *              00  *
   3       6.00000E+00 -  6.00000E+00     *  00              *
           6.00000E+00 -  6.00000E+00     *                  *
   4       6.00000E+00 -  6.00000E+00     *                  *
           6.00000E+00 -  6.00000E+00     ********************
   5       6.00000E+00 -  6.00000E+00     MAXIMUM VALUE= 6.00000E+00      MINIMUM VALUE= 6.00000E+00
           6.00000E+00 -  6.00000E+00
   6       6.00000E+00 -  6.00000E+00
           6.00000E+00 -  6.00000E+00
   7       6.00000E+00 -  6.00000E+00
           6.00000E+00 -  6.00000E+00
   8       6.00000E+00 -  6.00000E+00
           6.00000E+00 -  6.00000E+00
   9       6.00000E+00 -  6.00000E+00
           6.00000E+00 -  6.00000E+00


SURFACE PLOT OF X DIFFUSIVITY
-------------------------------
        CONTOUR LEVELS
        --------------
PLOT CHAR          INTERVAL
                                          ********************
   0       1.00000E+00 -  1.71316E-01     *6666            66*
           1.71316E-01 -  3.42633E-01     *6666  77777777  66*
   1       3.42633E-01 -  5.13949E-01     *                  *
           5.13949E-01 -  6.85265E-01     *        99  00    *
   2       6.85265E-01 -  8.56581E-01     *        77  00    *
           8.56581E-01 -  1.02790E+00     *        99  00    *
   3       1.02790E+00 -  1.19921E+00     *                  *
           1.19921E+00 -  1.37053E+00     *6666  77777777  66*
   4       1.37053E+00 -  1.54185E+00     *6666            66*
           1.54185E+00 -  1.71316E+00     ********************
   5       1.71316E+00 -  1.88448E+00     MAXIMUM VALUE= 3.42632E+00      MINIMUM VALUE= 0.00000E+00
           1.88448E+00 -  2.05580E+00
   6       2.05580E+00 -  2.22711E+00
           2.22711E+00 -  2.39843E+00
   7       2.39843E+00 -  2.56974E+00
           2.56974E+00 -  2.74106E+00
   8       2.74106E+00 -  2.91238E+00
           2.91238E+00 -  3.08369E+00
   9       3.08369E+00 -  3.25501E+00
```

5.25591E+01 - 5.02633E+00

SURFACE PLOT OF Y-DIFFUSIVITY

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
	0.00000E+00 - 2.11379E+01	
0	2.11379E+01 - 4.22758E+01	
	4.22758E+01 - 6.34137E+01	
1	6.34137E+01 - 8.45516E+01	
	8.45516E+01 - 1.05690E+02	
2	1.05690E+02 - 1.26827E+02	
	1.26827E+02 - 1.47965E+02	
3	1.47965E+02 - 1.69103E+02	
	1.69103E+02 - 1.90241E+02	
4	1.90241E+02 - 2.11379E+02	
	2.11379E+02 - 2.32517E+02	
5	2.32517E+02 - 2.53655E+02	
	2.53655E+02 - 2.74793E+02	
6	2.74793E+02 - 2.95931E+02	
	2.95931E+02 - 3.17069E+02	
7	3.17069E+02 - 3.38207E+02	
	3.38207E+02 - 3.59344E+02	
8	3.59344E+02 - 3.80482E+02	
	3.80482E+02 - 4.01620E+02	
9	4.01620E+02 - 4.22758E+02	



MAXIMUM VALUE= 4.22758E+02 MINIMUM VALUE= 0.00000E+00

CONCENTRATION AT TIME 2 HOURS AFTER START OF SIMULATION

SURFACE PLOT OF TRACER UG/M**3

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
0	0.000000E+00 - 5.741978E-01	
	5.741978E-01 - 1.148396E+01	
1	1.148396E+01 - 1.722594E+01	
	1.722594E+01 - 2.296792E+01	
2	2.296792E+01 - 2.870990E+01	
	2.870990E+01 - 3.445188E+01	
3	3.445188E+01 - 4.019386E+01	
	4.019386E+01 - 4.593584E+01	
4	4.593584E+01 - 5.167782E+01	
	5.167782E+01 - 5.741978E+01	
5	5.741978E+01 - 6.316176E+01	
	6.316176E+01 - 6.890374E+01	
6	6.890374E+01 - 7.464572E+01	
	7.464572E+01 - 8.038770E+01	
7	8.038770E+01 - 8.612968E+01	
	8.612968E+01 - 9.187166E+01	
8	9.187166E+01 - 9.761364E+01	
	9.761364E+01 - 1.033556E+02	
9	1.033556E+02 - 1.090976E+02	
	1.090976E+02 - 1.148396E+02	

MAXIMUM VALUE= 1.148396E+02 MINIMUM VALUE= 0.000000E+00

SURFACE PLOT OF SO_2 ppm

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
0	0.000000E+00 - 2.460375E-02	
	2.460375E-02 - 4.921500E-02	
1	4.921500E-02 - 7.382625E-02	
	7.382625E-02 - 9.843800E-02	
2	9.843800E-02 - 1.230488E-01	
	1.230488E-01 - 1.476600E-01	
3	1.476600E-01 - 1.722713E-01	
	1.722713E-01 - 1.968825E-01	
4	1.968825E-01 - 2.214938E-01	
	2.214938E-01 - 2.461050E-01	
5	2.461050E-01 - 2.707163E-01	
	2.707163E-01 - 2.953275E-01	
6	2.953275E-01 - 3.199388E-01	
	3.199388E-01 - 3.445500E-01	
7	3.445500E-01 - 3.691613E-01	
	3.691613E-01 - 3.937725E-01	

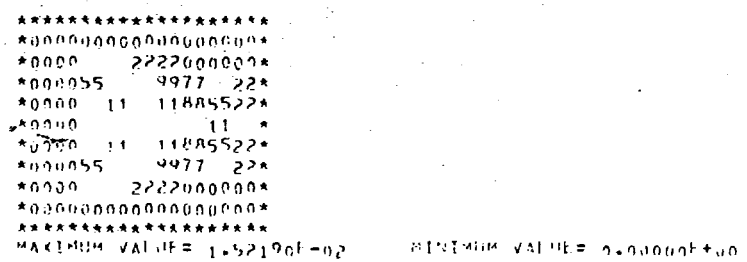
MAXIMUM VALUE= 3.937725E-01 MINIMUM VALUE= 0.000000E+00

8	3.93728E-01	-	4.18328E-01
	4.18328E-01	-	4.42935E-01
9	4.42935E-01	-	4.67543E-01
	4.67543E-01	-	4.92150E-01

SURFACE PLOT OF SO_4 ppm

CONTOUR LEVELS

PLOT CHAR	INTERVAL		
			**********
0	0.00000E+00	-	7.60952E-04
	7.60952E-04	-	1.52190E-03
1	1.52190E-03	-	2.28286E-03
	2.28286E-03	-	3.04381E-03
2	3.04381E-03	-	3.80476E-03
	3.80476E-03	-	4.56571E-03
3	4.56571E-03	-	5.32667E-03
	5.32667E-03	-	6.08762E-03
4	6.08762E-03	-	6.84857E-03
	6.84857E-03	-	7.60952E-03
5	7.60952E-03	-	8.37047E-03
	8.37047E-03	-	9.13143E-03
6	9.13143E-03	-	9.89238E-03
	9.89238E-03	-	1.06533E-02
7	1.06533E-02	-	1.14143E-02
	1.14143E-02	-	1.21752E-02
8	1.21752E-02	-	1.29362E-02
	1.29362E-02	-	1.36971E-02
9	1.36971E-02	-	1.44581E-02
	1.44581E-02	-	1.52190E-02



2-HOUR AVERAGED CONCENTRATIONS

SURFACE PLOT OF TRACER UG/M**3

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	0.00000E+00 - 2.30217E+00	*0000000000000000*
	2.30217E+00 - 4.60434E+00	*0000 00000000*
1	4.60434E+00 - 6.90652E+00	*000044 2211 00*
	6.90652E+00 - 9.20869E+00	*00 00000011 00*
2	9.20869E+00 - 1.15109E+01	*00 66 11 *
	1.15109E+01 - 1.38130E+01	*00 00000011 00*
3	1.38130E+01 - 1.61152E+01	*000044 2211 00*
	1.61152E+01 - 1.84174E+01	*0000 00000000*
4	1.84174E+01 - 2.07196E+01	*0000000000000000*
	2.07196E+01 - 2.30217E+01	**********
5	2.30217E+01 - 2.53239E+01	MAXIMUM VALUE= 4.60434E+01 MINIMUM VALUE= 0.00000E+00
	2.53239E+01 - 2.76261E+01	
6	2.76261E+01 - 2.99282E+01	
	2.99282E+01 - 3.22304E+01	
7	3.22304E+01 - 3.45326E+01	
	3.45326E+01 - 3.68348E+01	
8	3.68348E+01 - 3.91369E+01	
	3.91369E+01 - 4.14391E+01	
9	4.14391E+01 - 4.37413E+01	
	4.37413E+01 - 4.60434E+01	

SURFACE PLOT OF SO_2 ppm

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	0.00000E+00 - 9.82893E-03	*0000000000000000*
	9.82893E-03 - 1.96579E-02	*0000 00000000*
1	1.96579E-02 - 2.94868E-02	*000044 2211 00*
	2.94868E-02 - 3.93157E-02	*00 1111 11 00*
2	3.93157E-02 - 4.91446E-02	*00 77 44 11 *
	4.91446E-02 - 5.89736E-02	*00 1111 11 00*
3	5.89736E-02 - 6.88025E-02	*000044 2211 00*
	6.88025E-02 - 7.86314E-02	*0000 00000000*
4	7.86314E-02 - 8.84604E-02	*0000000000000000*
	8.84604E-02 - 9.82893E-02	**********
5	9.82893E-02 - 1.08118E-01	MAXIMUM VALUE= 1.96578E-01 MINIMUM VALUE= 0.00000E+00
	1.08118E-01 - 1.17947E-01	
6	1.17947E-01 - 1.27776E-01	
	1.27776E-01 - 1.37605E-01	
7	1.37605E-01 - 1.47434E-01	
	1.47434E-01 - 1.57263E-01	

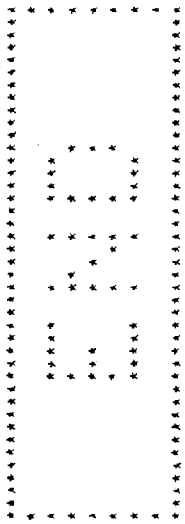
8	1.57263E-01 -	1.67092E-01
	1.67092E-01 -	1.76921E-01
9	1.76921E-01 -	1.86750E-01
	1.86750E-01 -	1.96579E-01

SURFACE PLOT OF SO_4 ppm

CONTOUR LEVELS

PLOT CHAR	INTERVAL	
		**********
0	0.00000E+00 -	2.56289E-04
	2.56289E-04 -	5.12578E-04
1	5.12578E-04 -	7.68868E-04
	7.68868E-04 -	1.02516E-03
2	1.02516E-03 -	1.28145E-03
	1.28145E-03 -	1.53774E-03
3	1.53774E-03 -	1.79402E-03
	1.79402E-03 -	2.05031E-03
4	2.05031E-03 -	2.30660E-03
	2.30660E-03 -	2.56289E-03
	**********	
5	2.56289E-03 -	2.81918E-03
	2.81918E-03 -	3.07547E-03
6	3.07547E-03 -	3.33176E-03
	3.33176E-03 -	3.58805E-03
7	3.58805E-03 -	3.84434E-03
	3.84434E-03 -	4.10063E-03
8	4.10063E-03 -	4.35692E-03
	4.35692E-03 -	4.61321E-03
9	4.61321E-03 -	4.86949E-03
	4.86949E-03 -	5.12578E-03

MAXIMUM VALUE= 5.12578E-03 MINIMUM VALUE= 0.00000E+00



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