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USER'S GUIDE FOR PEM-2:

POLLUTION EPISODIC MODEL (VERSION 2)

ATMOSPHERIC SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

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by

K. Shankar Rao
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
Oak Ridge, Tennessee 37830

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Project Officer

James M. Godowitch
Meteorology and Assessment Division
Atmospheric Sciences Research Laboratory
Research Triangle Park, North Carolina 27711

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NOTICE

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PREFACE

This report contains a technical description and complete user instructions for the Pollution Episodic Model Version 2 (PEM-2) computer program. The PEM-2 urban air quality dispersion model was developed to simulate the relevant physical processes in order to predict short-term ground level concentrations of particulate matter and/or gaseous pollutants from multiple point and area sources over an urban domain. Gaussian plume modeling techniques were adapted to allow for dry deposition processes by a gradient transfer approach and a chemical reaction between two species by a linear transformation method. The deposition and settling velocities for each species, and a transformation rate constant must be specified by the user. The model algorithms are subject to specific assumptions and limitations described in the report. PEM-2 is currently a non-guideline model.

Input requirements include source characteristics and emission rates, hourly measurements of meteorological parameters, and upwind boundary concentration. The latter should be representative of the incoming regional background measured sufficiently upwind of the urban emissions region. A comprehensive quality-assured emissions inventory and representative, accurate meteorological and concentration measurements aid in reducing model uncertainty.

The computer code has been thoroughly tested with example cases; however, errors are occasionally discovered and revisions may be made. Future revisions may be obtained if issued by completing and returning the form on the last page of this publication. Comments and questions about this publication should be directed to; Chief, Atmospheric Modeling Branch, Meteorology and Assessment Division (MD-80), Environmental Protection Agency, Research Triangle Park, NC 27711.

This user guide is available from the National Technical Information Service (NTIS), Springfield, VA 22161. The computer code is contained on the UNAMAP Version 6 magnetic tape and it may be obtained from Computer Products, NTIS, Springfield, VA 22161 (phone: (703) 487-4763).

ABSTRACT

The Pollution Episodic Model Version 2 (PEM-2) is an urban-scale model designed to predict short term average ground-level concentrations and deposition fluxes of one or two gaseous or particulate pollutants at multiple receptors. The two pollutants may be non-reactive, or chemically-coupled through a first-order chemical transformation. Up to 300 isolated point sources and 50 distributed area sources may be considered in the calculations. Concentration and deposition flux estimates are made using hourly mean meteorological data. Up to a maxiumum of 24 hourly scenarios of meteorology may be included in an averaging period.

The concentration algorithms used in PEM-2 are specially developed to account for the effects of dry deposition, sedimentation, and first-order chemical transformation. The Gaussian plume-type algorithms for point sources are derived from analytical solutions of a gradient-transfer model. In the limit, when deposition and settling velocities of the pollutants and the chemical transformation rate are zero, these expressions reduce to the familiar Gaussian plume diffusion algorithms. The concentrations from area sources in PEM-2 are calculated by numerical integration of the point source algorithms.

When the chemical transformation option is considered, PEM-2 calculates the average surface concentrations and deposition fluxes of both the primary (reactant) and the secondary (reaction product) pollutants. The model also permits a possible direct emission of the secondary pollutant. The deposition and settling velocities of the two species may be different. Either of the species may be a gaseous or particulate pollutant. PEM-2 is intended for studies of the atmospheric transport, transformation, and deposition of acidic, toxic, and other pollutants in urban areas to assess the impact of existing or new sources or source modifications on air quality for regulatory purposes and urban planning.

The User's Guide lists the concentration algorithms and computational techniques used in the PEM-2 program, and describes the input/output parameters, optional features, capabilities, and limitations of the model. Modifications to the previos version of the model are outlined. The information contained in this report is directed to the model user and the programmer.

This User's Guide to PEM-2 was prepared by NOAA's Atmospheric Turbulence and Diffusion Division in partial fulfillment of an Interagency Agreement with the U.S. Environmental Protection Agency. This work, covering the period December 1983 to July 1984, was completed as of September 30, 1984.

CONTENTS

Preface iii

Abstract iv

Figures vii

Tables viii

Acknowledgements ix

1. MODEL OVERVIEW

1.1 Introduction 1

1.2 Capabilities and Applications 2

1.3 Assumptions and Limitations 3

1.4 Summary of Input Data 5

1.5 Summary of Model Output 7

2. TECHNICAL DISCUSSION

2.1 Theoretical Basis 9

2.2 Point Sources 10

2.2.1 Concentration Algorithms 10

2.2.2 Plume Rise 12

2.2.3 Dispersion Parameters 13

2.2.4 Restrictions on Receptors for Calculations 14

2.3 Area Sources 15

2.3.1 Emission Grid 15

2.3.2 Concentration Algorithms 21

2.3.3 Dispersion Parameters 24

2.4 Receptors 24

2.4.1 Receptor Grid 24

2.4.2 Automatic Grid Selection 25

2.5 Meteorology 30

2.5.1 Atmospheric Stability 31

2.5.2 Wind Speed 32

2.5.3 Wind Direction 34

2.5.4 Mixing Depth 35

3. COMPUTER PROGRAM OVERVIEW

3.1 Basis for PEM-2 Program 37

3.2 Structure of the Program 38

3.3 General Flow of the Program 40

4. PROGRAM USER'S GUIDE

4.1 Summary of Program Input 42

4.2 Details of Program Input 43

4.2.1 Control Parameters 43

4.2.2 Scenario Parameters 50

4.2.3 Area Source Parameters..... 51

4.2.4 Point Source Parameters 52

4.3 Guide to Program Output 53

4.4 Discussion of I/O Parameters 55

4.5 Example Problems 58

References 60

Appendices

A. Point Source Algorithms 61

B. Plume Rise Equations and Plume Penetration Methods 70

C. Surface Deposition Fluxes, and Deposition and Settling Velocities 85

D. D01AJF - NAG FORTRAN Library Routine Document 88

E. Input and Output Listings of Example Problems 92

F. PEM-2 FORTRAN Listing 147

FIGURES

Number		Page
1.	Schematic diagram showing a single grid square with emissions and four downwind calculation grid squares with receptors, and the distances used in area-source algorithms. These distances are measured downwind from the source Q_o	17
2.	Spatial patterns of affected calculation grid squares downwind of an area source	18-19
3.	Points used for automatic selection of receptor grid by AUTGRD subroutine	27
4.	Example of a receptor grid selected by AUTGRD subroutine	29
5.	Structure of PEM-2 computer program	39

TABLES

Number		Page
1	Values of coefficients in the formulas for $\sigma_y(x)$ and $\sigma_z(x)$ in urban conditions	14
2	Maximum crosswind half-angle values for point source plumes	15
3	Values of i and j for each spatial pattern of affected squares downwind of an area source	20
4	Atmospheric stability classes	31
5	Atmospheric conditions defining stability classes	31
6	Wind speed classification	32
7	Values of exponent p in wind speed power law	33
8	Wind direction sectors	34

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Several figures and tables shown in this report are reproduced from the Users' Guide to Texas Episodic Model with permission from the Texas Air Control Board. The library routine D01AJF used for numerical integration in PEM-2 has been released by the Computer Sciences Division of the Oak Ridge National Laboratory for inclusion in the program listing. The Numerical Algorithms Group (NAG) holds the copyright to this routine and its document. The latter is reproduced in this report from the NAG FORTRAN Mini-Manual.

SECTION 1

MODEL OVERVIEW

1.1 INTRODUCTION

The Pollution Episodic Model Version 2 (PEM-2) is an urban-scale air quality model designed to predict short term ground-level concentrations and deposition fluxes of one or two, gaseous or particulate, reactive or non-reactive pollutants in an urban area with multiple point and area sources. PEM-2 uses the concentration algorithms developed by Rao (1982) which explicitly account for the effects of dry deposition, gravitational settling, and a first-order chemical transformation. These algorithms, derived analytically from a gradient-transfer model, are based on Gaussian plume modeling assumptions. For chemically-coupled pollutants, the surface concentrations and deposition fluxes of both the primary (reactant) and the secondary (reaction product) pollutant are calculated.

PEM-2 is based on the Pollution Episodic Model (PEM) developed by Rao and Stevens (1982). The latter, in turn, is based on the Texas Episodic Model Version 8 (TEM-8) developed by the Texas Air Control Board (1979) for the atmospheric dispersion of non-reactive pollutants over a perfectly reflecting (non-depositing) surface. In the limit, when the deposition and settling velocities and the chemical transformation rate are zero, the concentration algorithms used in PEM-2 reduce to the familiar Gaussian plume dispersion algorithms used in TEM-8. The two models share essentially the same framework for calculations, though there are differences in the computational techniques utilized in the models.

Besides the concentration algorithms, there are other important differences between PEM-2 and TEM-8 models:

1. PEM-2 uses Briggs' (1973) urban dispersion parameters for both point and area sources to represent 1-hour average dispersion. This treatment is similar to that used in EPA's RAM model (Turner and Novak, 1978). TEM-8 uses the Pasquill-Gifford (PG) curves to represent 10-minute average dispersion from point sources; for averaging periods longer than 10 minutes, the σ_y values are adjusted to account for the greater horizontal plume meander due to fluctuations in wind direction. For area sources, TEM-8 uses the σ_z's from Gifford and Hanna (1970) to represent 1-hour average dispersion.

2. PEM-2 determines the concentrations for a period longer than an hour by summing and averaging the concentrations calculated for each hour in the period. TEM-8 does not do this time-averaging for concentrations from area sources. Thus, with a constant meteorology for N hours, the area-source concentration at a receptor predicted by TEM-8 would be N times its hourly concentration.

3. TEM-8 estimates the point source concentrations by interpolating between the relative concentrations precalculated for selected values of model parameters and stored in large look-up tables. Because of the large number of model parameters, PEM-2 does not use this interpolation technique.

Other differences between these two models are listed in Section 3.

1.2 CAPABILITIES AND APPLICATIONS

The capabilities of PEM-2 are as follows:

1. PEM-2 is an urban-scale air quality model applicable to downwind distances of up to 50 km. Up to a maximum of 300 point sources and 50 area sources can be included in the model inputs to estimate concentrations at a maximum of 2500 receptors located on a 50 x 50 square receptor grid.

2. PEM-2 calculates short-term (1 to 24 hr) average ground-level concentrations and deposition fluxes of one or two gaseous or particulate pollutants.

3. The two pollutants may be non-reactive, or chemically-coupled through a first-order chemical transformation. If only one pollutant is calculated, the effects of a first-order chemical decay can be considered. The chemical transformation (or decay) rate may vary from 0.1 to 100 percent per hour.

4. The deposition (and settling) velocities of the two species may be equal or different. Direct emission of the secondary (reaction product) pollutant can be considered for both point and area sources.

Some areas of potential application of PEM-2 are the following:

1. Urban particulate modeling.

2. Studies of the transport, diffusion, transformation, and deposition of acidic, toxic, and other pollutants in urban areas. An important example is the atmospheric transport and transformation of SO_2 to $SO_4^=$.

3. Impact analyses of existing or new sources or source modifications for regulatory purposes and urban planning.

4. Stack design, and fuel conversion/switching studies. Evaluation of pollution control technology and strategies for prevention of significant deterioration.

1.3 ASSUMPTIONS AND LIMITATIONS

PEM-2 is based on steady state Gaussian plume modeling assumptions.

Some of the important assumptions of PEM-2 are as follows:

1. Concentration estimates may be made for each hour using the mean meteorological conditions for that hour. Average concentrations for a period longer than an hour are determined in the program by averaging the hourly concentrations of that period.

2. The sources are stationary and the emission rates are constant over the concentration-averaging period. The latter assumption is reasonable since PEM-2 is designed to predict only short-term average concentrations; this assumption is intended solely to limit the amount of input data required by the model.

3. If the hourly emission rates are highly variable over the concentration-averaging period, then the average concentrations may be obtained by averaging externally, with minimal programming, the concentrations calculated hourly and stored on tape by the model. This can be done, for example, to calculate the daily mean concentrations with diurnally varying emission rates.

4. Total concentration at a receptor is the sum of the concentrations calculated at the receptor from each source; i.e., concentrations are additive.

5. Pollutants released from a stack are transported downwind at a rate equal to the mean wind speed at the physical stack height. The wind direction is constant for each hour. The horizontal wind field is homogeneous and the effects of directional wind shear are neglected.

6. Diffusion of continuous plumes gives time-averaged Gaussian distributions for concentrations in the crosswind and vertical directions. The diffusion in the downwind direction is negligible compared to advection. This assumption obviously excludes calm conditions.

7. The reactant and the product species are coupled through a first-order chemical transformation. The deposition and settling velocities of the species, and the chemical transformation rate are constant over the concentration-averaging period. The diurnal variation of these parameters can be considered, if necessary, by averaging the hourly concentrations as discussed above.

8. Particulate pollutants consist of particles of a known size (or size distribution) with a representative settling velocity.

9. Pollutant concentration at a receptor due to the distributed area sources depends only on sources located in a narrow upwind sector. Therefore, horizontal diffusion can be ignored for area sources.

10. The crosswind variations of urban area source-strength patterns can be ignored. The contributions of more remote upwind area sources to the concentration at a receptor are quite small. For this reason, it is generally adequate to consider only eight area source grid squares immediately upwind of each receptor grid square.

Every air pollution model is limited by the assumptions used to predict the pollutant concentrations in the atmosphere. PEM-2 is subject to the same basic limitations as any Gaussian plume-type model. The limiting assumptions of the concentration algorithms developed for PEM-2 are discussed in detail by Rao (1982). Other general limitations of the model can be summarized as follows:

1. Receptors farther than 50 km downwind of a source are ignored. Thus the maximum downwind distance is limited to 50 km.

2. The number of point sources is limited to 300, and the number of area sources is limited to 50. The computer program can be easily modified by the user to increase the maximum number of point and/or area sources, if necessary. All sources are stationary.

3. The maximum number of scenarios (sets of hourly meteorological data) in an averaging period is limited to 24. PEM-2 is designed to calculate only short-term (1 to 24 hr) average surface concentrations and deposition fluxes of one or two pollutants.

4. PEM-2 does not make any adjustment for differences in terrain elevation between sources and/or receptors. The model assumes level terrain. No adjustments are made for building wake-induced downwash, wake entrainment, or other building-related effects on the various effluent plumes.

5. Only a first-order chemical transformation/decay is considered. The transformation rate, and the deposition and settling velocities of the species, must be specified by the user, if these options are selected.

6. The model cannot perform calculations for calm conditions; if such conditions occur, the wind speed is arbitrarily set to 1 m/s.

7. PEM-2 does not attempt to deal with wet removal processes; hence, the model does not apply during periods of precipitation.

1.4 SUMMARY OF INPUT DATA

Input to PEM-2 is divided into four main sections:

1) Control parameters

Control parameters remain constant throughout the model run. They specify:

1. An alphanumeric title

2. Time-averaging option

3. Options for types of input and output

4. Number of scenarios (sets of hourly meteorological data)

5. Options for using stack-tip downwash, new plume rise and new plume penetration schemes for point sources

6. Receptor grid coordinates and spacing

7. Automatic receptor grid option

8. Potential temperature gradient $d\theta/dz$ for calculation of plume rise with E and F atmospheric stability classes

9. Parameters for one or two pollutants:

   a) Deposition velocity
   b) Gravitational settling velocity

10. Option to calculate chemical transformation or decay of first pollutant

    a) Chemical transformation or decay rate
    b) Ratio of molecular weights of product to reactant

11. Scaling factors for area source emission rates

12. Calibration coefficients to be applied to the calculated concentrations

13. Alphanumeric labels for pollutants

14. Alphanumeric labels for the calibrated concentrations

15. Site-specific values of anemometer height and/or wind-profile exponents (optional)

2) Scenario Parameters

A scenario is a set of mean meteorological data for one hour. From one to twenty-four scenarios may be included in each run. Each scenario uses the same receptor grid and the same point and area source inventories. Meteorological parameters for each scenario are:

1. Atmospheric stability class

2. Wind speed class or specific wind speed

3. Wind direction sector or specific wind direction

4. Ambient temperature

5. Mixing height

6. Potential temperature gradient in the elevated stable layer above mixing height

3) Area Source Inventory

From zero to fifty area sources may be included in each run. Each area source square is described by:

1. Location in receptor grid coordinates

2. Length of a side

3. Emission rates for pollutants

4) Point Source Inventory

From zero to three hundred point sources may be included in each run. Each point source is described by:

1. Location in receptor grid coordinates

2. Emission rates for pollutants

3. Stack height

4. Inside diameter of the stack-tip

5. Exit velocity of the plume

6. Exit temperature of the plume

7. Alphanumeric identification

Details of the input data to PEM-2 are given in Section 4 of this report.

1.5 SUMMARY OF MODEL OUTPUT

For ease of reference, PEM-2 prints out and briefly explains all I/O control parameters and technical options used in a run. Input data for meteorological conditions, area sources, and point sources are also listed.

Calculated values of surface concentrations, deposition fluxes, and other useful information may be displayed in the following optional forms:

1. List Option --- For each receptor in the grid, the calculated values of concentrations and deposition fluxes are listed at the end of each averaging-period consisting of 1 to 24 scenarios.

2. Spatial Array Option --- The calculated values of concentrations and deposition fluxes at each receptor are displayed in map form at the end of each averaging-period.

3. Tape Option --- The calculated values of concentrations and deposition fluxes at each receptor are written on a magnetic tape (designated for output) at the end of each averaging-period. This option may be used to generate inputs to a contour-plotting routine, or to store hourly output data for averaging externally in order to account for the variability of hourly emission rates in an averaging-period consisting of more than one scenario (see Section 1.3).

4. Culpability List Option --- The five point sources which contributed most to the total concentration at each receptor are identified by point-source sequence number. A list of these source numbers and their percent contributions are printed for one or two pollutants at each receptor in the grid at the end of each scenario.

5. Maximum Concentration Option --- The maximum calculated values of surface concentration and deposition flux, and the receptor where these values occur, are printed for each pollutant at the end of the last scenario or averaging-period.

6. Point Source List Option --- The input stack parameters, the wind speed at physical stack height, the maximum effective source height, the dominant plume rise influence (buoyancy or momentum), and the plume penetration fraction (see Appendix B) are listed for each point source at the beginning of each scenario.

These output options are selected by the user by specifying appropriate values for the control parameters in the inputs to the model. It may not be possible to select some of these options in combination with others. The details are discussed in Section 4.

SECTION 2

TECHNICAL DISCUSSION

2.1 THEORETICAL BASIS

The concentration algorithms used in PEM-2 are derived from analytical solutions of a steady state gradient-transfer (K-theory) model, which describes the atmospheric transport, diffusion, deposition, and first-order chemical transformation of gaseous or particulate pollutants from an elevated continuous point source. The eddy diffusivity coefficients in these analytical solutions are expressed in terms of the empirical Gaussian plume dispersion parameters, so that the latter can be conveniently specified as functions of the downwind distance and the atmospheric stability class within the framework of the standard turbulence-typing schemes. The point-source concentration algorithms for the primary (reactant) and the secondary (product) pollutants are presented for various stability and mixing conditions of the atmosphere. In the limit when deposition and settling velocities and the chemical transformation rate are zero, these algorithms reduce to the well-known Gaussian plume dispersion algorithms presently used in EPA air quality models. Details of the gradient-transfer model formulations, analytical solutions, parameterizations, and development of the point-source concentration algorithms can be found in the reports by Rao (1981, 1982).

In PEM-2, the ground-level concentrations of the primary and secondary pollutants resulting from urban area source emissions are computed by numerical integration of the corresponding point-source concentration algorithms. The urban area-source modeling techniques of Gifford and Hanna (1970) are utilized in these computations. For point sources, PEM-2 provides options for using the standard or new plume rise formulations due to Briggs (1969, 1984), and new schemes for plume penetration of an elevated stable layer. For both point and area sources, PEM-2 uses the urban dispersion parameters of Briggs (1973) as given by Gifford (1976).

2.2 POINT SOURCES

2.2.1 Concentration Algorithms

The ground-level concentrations of the primary and the secondary pollutants (denoted by subscripts 1 and 2, respectively) from an elevated continuous point source are calculated in PEM-2 from one or both of the following sets of algorithms, depending on the atmospheric stability and mixing conditions:

Near-source region ($0 < x \leq x_m$),

$$C_1 = \frac{Q_1}{U} \cdot \frac{g_1}{L_y} \cdot \frac{g'_{21}}{L_z} \tag{1a}$$

$$C_2 = \frac{Q_1}{U} \cdot \frac{g_1}{L_y} \cdot \frac{g'_{22}}{L_z} \tag{1b}$$

Well-Mixed region ($x \geqq 2\ x_m$)

$$C_1 = \frac{Q_1}{U} \cdot \frac{g_1}{L_y} \cdot \frac{g'_{41}}{L} \tag{2a}$$

$$C_2 = \frac{Q_1}{U} \cdot \frac{g_1}{L_y} \cdot \frac{g'_{42}}{L} \tag{2b}$$

where $$L_y = \sqrt{2\pi}\ \sigma_y\ , \quad L_z = \sqrt{2\pi}\ \sigma_z \tag{3}$$

In the above, Q_1 is emission rate (source strength) of the primary pollutant, U is mean wind speed at physical stack height, L is mixing depth (height of inversion lid), x_m is the downwind distance (from source) determined such that $\sigma_z(x_m) = 0.47$ L, and L_y and L_z are length scales characteristic of diffusion in the horizontal crosswind and vertical directions, respectively. The nondimensional functions $g_1(\hat{x},\hat{y})$, $g'_{21}(\hat{x},0)$, $g'_{22}(\hat{x},0)$, $g'_{41}(\hat{x})$, and $g'_{42}(\hat{x})$, defined in terms of dimensionless parameterized variables, are given in Appendix A.

In Eqs. (1) and (2), it should be noted that the concentrations for both primary and secondary pollutants are expressed in terms of Q_1. This does not preclude consideration of a non-zero value for Q_2, the direct emission rate of the secondary pollutant. The algorithms for g'_{22} and g'_{42} provide for this possibility.

The well-mixed region algorithms, Eq. (2), are generally used under convective or neutral stability conditions. The ground-level plume centerline concentrations of the species in the plume-trapping region ($x_m < x < 2x_m$)

can be obtained by calculating the concentrations at x_m and $2x_m$ from Eqs. (1) and (2), and interpolating between these values on a log-log plot of concentrations versus downwind distance (Turner, 1970). PEM-2 uses this interpolation approach in the plume-trapping region.

2.2.2 Plume Rise

Plume rise is calculated from the standard or new equations given by Briggs (1969, 1984). The stack-exit conditions of the plume and the ambient temperature determine whether the upward motion of the plume is dominated by momentum or buoyancy. For atmospheric stability classes A to D, the unstable/neutral plume rise equations are used. For stability classes E and F, the stable plume rise equations are used. Thus, there are four different situations for plume rise:

(1) buoyancy-dominated plume in unstable/neutral atmosphere,

(2) momentum-dominated plume in unstable/neutral atmosphere,

(3) buoyancy-dominated plume in stable atmosphere, and

(4) momentum-dominated plume in stable atmosphere.

In each situation except the last one, the plume rise is calculated as a function of downwind distance from the stack until the final plume rise is attained. The standard plume rise equations for these four cases, the optional stack-tip downwash correction following Briggs (1973), and the crossover techniques used in PEM-2 to determine whether the plume is dominated by momentum or buoyancy are listed in Appendix B. The optional new equations of Briggs (1984) for estimating the maximum rise of a buoyancy-dominated plume in unstable/neutral atmosphere, and new schemes for plume penetration of an elevated stable layer are also given in this Appendix.

2.2.3 Dispersion Parameters

The Gaussian dispersion parameters, σ_y and σ_z, used in PEM-2 for each scenario are identical to those used in EPA's RAM model (Turner and Novak, 1978) to represent a 1-hour average dispersion over urban areas. Assuming a rectangular cross-section for the plume, Briggs (1973) gave interpolation formulas for these urban diffusion coefficients, which are based on the diffusion data from near-surface releases of a neutrally-buoyant tracer in St. Louis by McElroy and Pooler (1968). The corresponding expressions for σ_y and σ_z for a Gaussian plume, based on Briggs' formulations, are given by Gifford (1976, Figure 7, Table 8). Hosker (1973) compared these urban dispersion parameter curves to the Pasquill-Gifford (PG) σ curves, and showed that their values are greater than all but the more unstable of the corresponding PG curves because of the enhanced mechanical and convective turbulence over an urban area compared to that over open country.

PEM-2 uses the expressions for Briggs' urban dispersion parameters given by Gifford (1976). These formulas are written in a convenient form for programming as follows:

$$\sigma_z(x) = a_z x \quad (1+c_z x)\ (1+b_z x)^{-1/2} \tag{4a}$$

$$\sigma_y(x) = a_y x \quad (1+0.0004x)^{-1/2} \tag{4b}$$

In Eq. (4), x is given in meters. The coefficients a_y, a_z, b_z, and c_z are functions of atmospheric stability class, and their values are shown in Table 1.

TABLE 1

Values of Coefficients in the Formulas for $\sigma_y(x)$ and $\sigma_z(x)$, Equation (4), in Urban Conditions

P-G Stability Class	a_y	a_z	b_z	c_z
A-B	.32	.24	.001	.001
C	.22	.20	0	0
D	.16	.14	.0003	0
E-F	.11	.08	.0015	0

2.2.4 Restrictions on Receptors for Calculations

Pollutants emitted from each point source may not contribute to all of the receptors in a grid. The receptors excluded from the calculations are those located upwind of the source, too far from the plume centerline, or more than 50 km downwind of the source. For each source and each scenario, PEM-2 selects a rectangular area of the receptor grid downwind of the source, and calculations for that set of conditions are restricted to the receptors located within that area. The source contribution is considered to be zero at receptors located outside the area. Model inputs used for determining this area are the source coordinates, grid boundaries, wind direction, and the crosswind angle (Δ) between wind direction azimuth and the azimuth from the source to the receptor. If Δ exceeds the maximum crosswind half-angle of the plume (Δ_{max}), then the receptor is excluded from calculations. The values of the maximum crosswind half-angle used in PEM-2 for 1-hour averaging of the plume are shown in Table 2 as a function of the atmospheric stability class.

TABLE 2

Maximum Crosswind Half-angle Values

for Point Source Plumes

Atmospheric Stability Class	Δ_{max} (degrees)
A-B	43
C	33
D	25
E-F	18

At x = 100 m, these Δ_{max} values give a maximum plume half-width of 3 σ_y for calculations in the lateral direction. For x > 100 m, the maximum half-width of the calculated plume is larger than 3 σ_y.

2.3 AREA SOURCES

2.3.1 Emission Grid

PEM-2 defines a "calculation grid" by shifting the receptor grid to the South and to the West by one-half the side of a grid square ($\Delta x/2$). Thus each square in the calculation grid has one receptor at its center, since the calculation grid squares are of the same size (Δx) as the receptor grid squares.

Each area source used in PEM-2 should be sized so that it covers an integral number of calculation grid squares. The size Δx should be defined such that the smallest area source is at least as large as one calculation grid square.

The relationship between area sources and calculation grid squares can be divided into three cases. In the first case, the area source is of the same size as a calculation grid square. Emissions (Q_o) are assumed to be located at the center of the square; contributions of this area source are determined at the receptor (R_o) located at the center of the emission grid square, and at the receptors (R_1 to R_8) located at the center of each of the eight calculation grid squares immediately downwind of the source. This is schematically illustrated in Fig. 1, which shows only the first five receptors R_o,----, R_4.

The location of the eight downwind squares is not apparent in cases when the wind direction is not parallel to one of the calculation grid coordinate axes as shown in Fig. 2. The angle, ξ, between the wind azimuth and the nearest calculation grid coordinate axis is defined such that $0 \leq \xi \leq 45°$. PEM-2 considers ten ranges of values for ξ as shown in Table 3. For each range of ξ, the location of each downwind square is denoted by i (the number of calculation grid squares downwind from the area source) and j (the number of calculation grid squares off the axis used to define ξ), as illustrated in Fig. 2. These patterns of squares are stored in PEM-2 data tables that list values of i and j as shown in Table 3. For a given scenario, each area source will have the same spatial pattern of affected squares downwind.

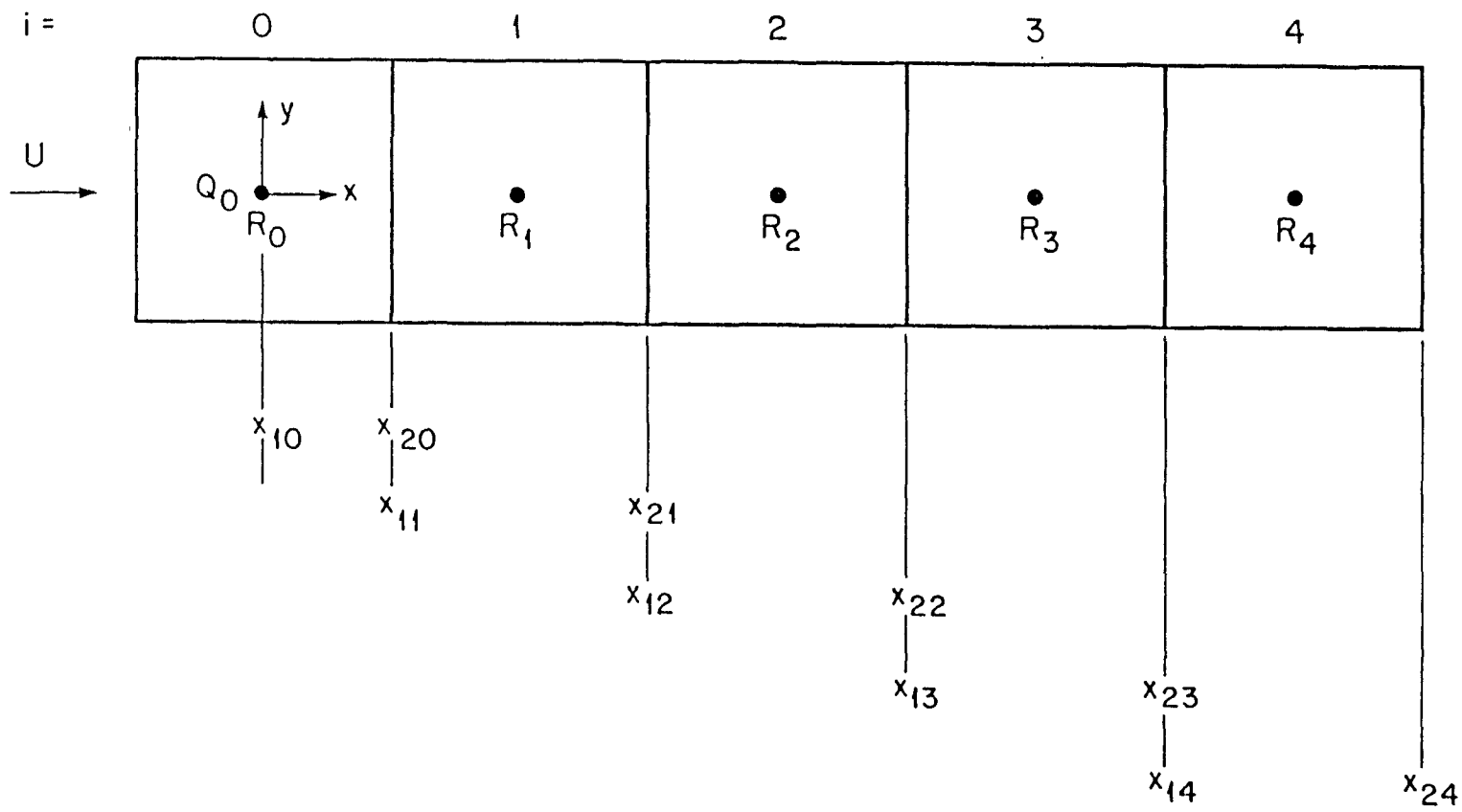

Figure 1. Schematic diagram showing a single grid square with emissions and four downwind calcuation grid squares with receptors, and the distances used in area-source algorithms. These distances are measured downwind from the source Q_o. PEM-2 considers eight downwind calculation grid squares (i.e., i=1,---,8) for each emission grid square (i=0).

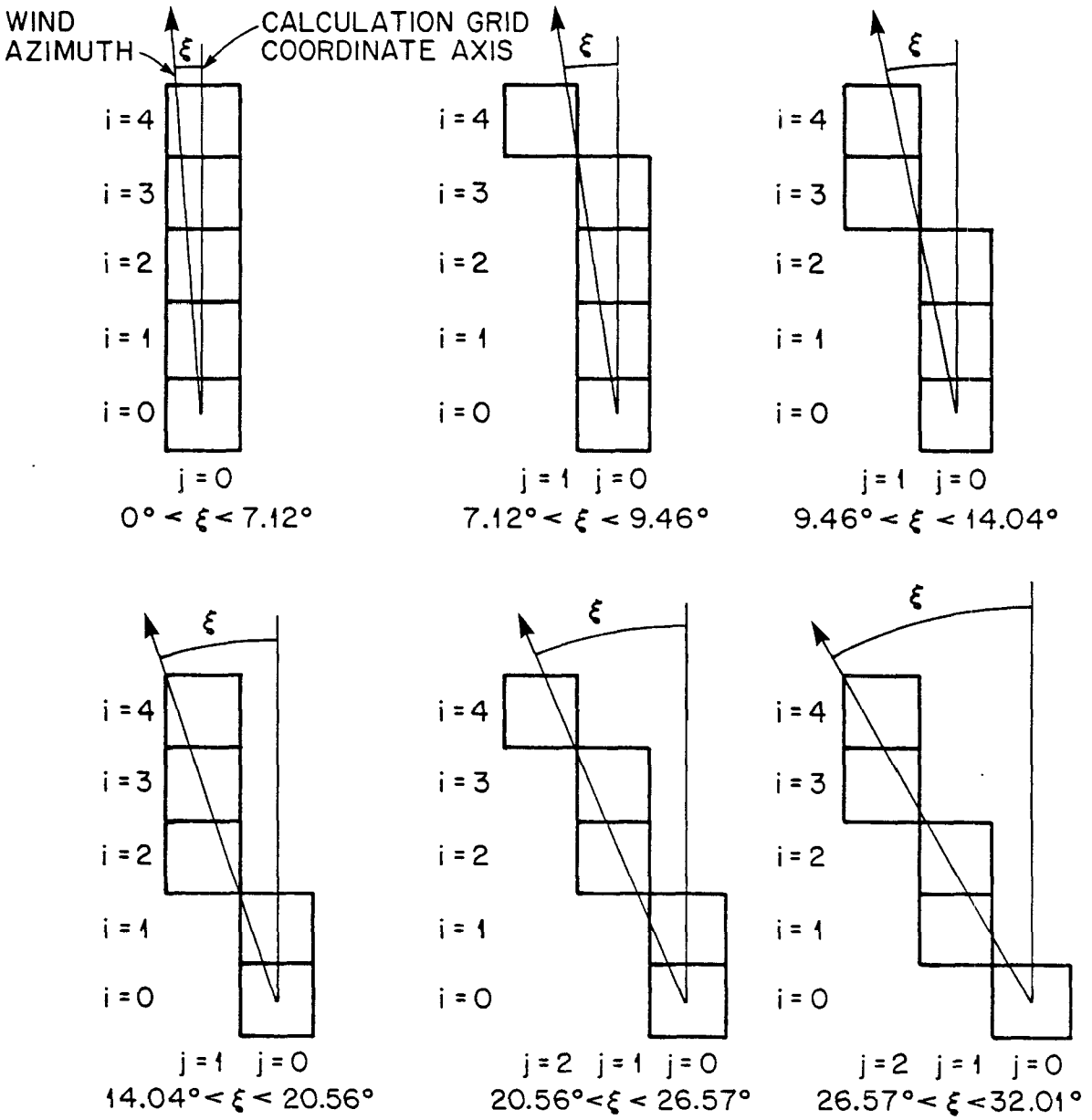

Figure 2. Spatial patterns of affected calculation grid squares downwind of an area source. PEM-2 considers eight (i.e., i=1,---,8) affected grid squares downwind of an area source (i=0), though only the first four are shown in this figure.

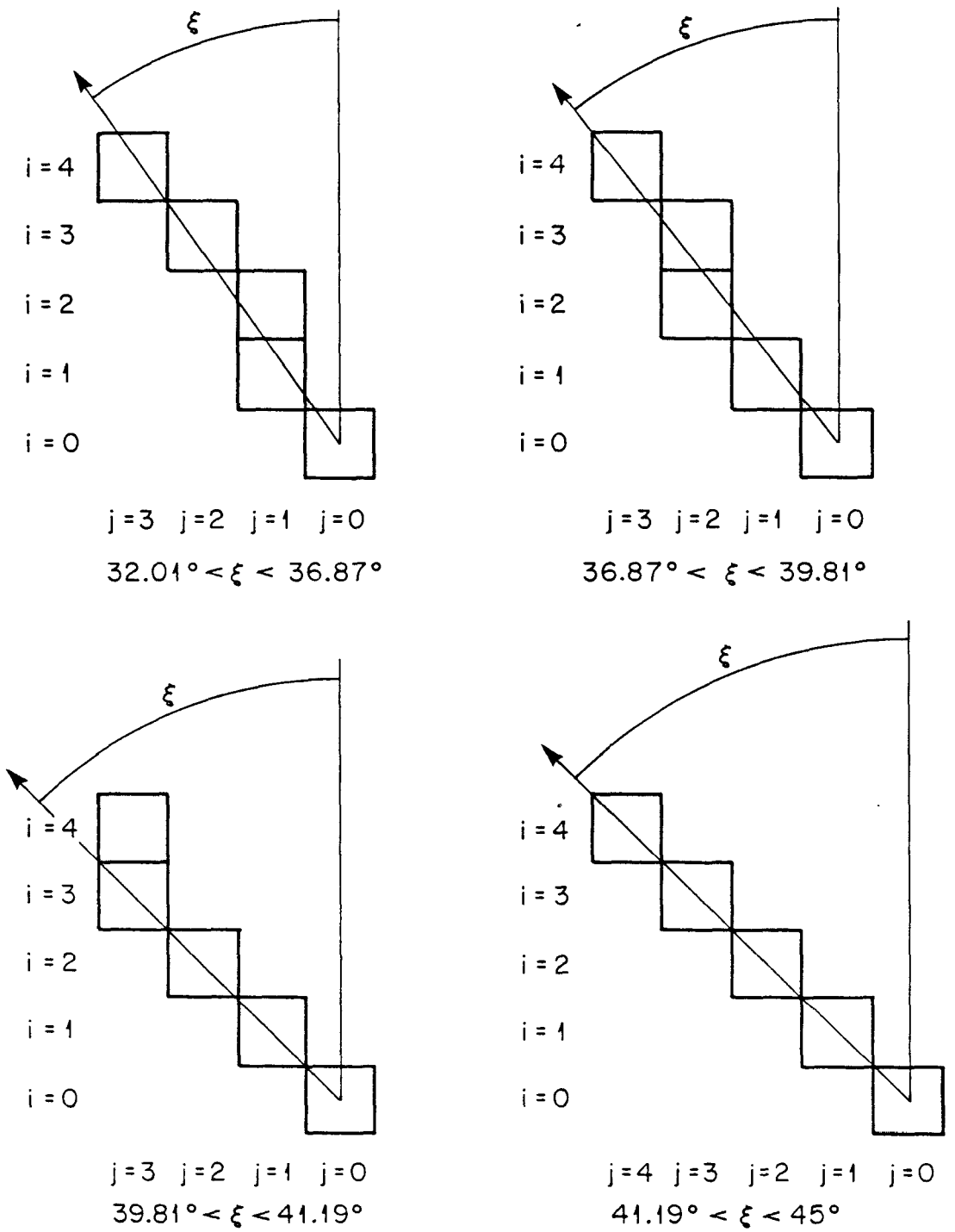

Figure 2. Continued.

TABLE 3

Values of i and j for Each Spatial Pattern of Affected Squares Downwind of an Area Source

ξ range, degrees	Values for j**								
	i=0*	i=1	i=2	i=3	i=4	i=5	i=6	i=7	i=8
0 - 7.12	0	0	0	0	0	0	0	0	0
7.12 - 9.46	0	0	0	0	1	1	1	1	1
9.46 - 14.04	0	0	0	1	1	1	1	1	2
14.04 - 20.56	0	0	1	1	1	2	2	2	2
20.56 - 26.57	0	0	1	1	2	2	3	3	3
26.57 - 32.01	0	1	1	2	2	3	3	4	4
32.01 - 36.87	0	1	1	2	3	3	4	5	5
36.87 - 39.81	0	1	2	2	3	4	5	6	6
39.81 - 41.19	0	1	2	3	3	4	5	6	7
41.19 - 45.00	0	1	2	3	4	5	6	7	8

*i is the number of calculation grid squares downwind from the area source

**j is the number of calculation grid squares off the axis used to define ξ

For each value of ξ, a diagram of the first four affected squares downwind of an area source in square i=0, j=0 is shown in Figure 2.

In the second case, the area source is larger than one calculation grid square. Let m be the number of calculation grid squares covered by the source of area A. Then the emissions, Q, from the source are divided into m component emission rates defined by

$$Q_j = Q\ A_j/A \quad , \quad j = 1,2, \ldots, m$$

where A_j is the area of the source contained in the jth square,

$$A = \sum_{j=1}^{m} A_j \qquad \text{and} \qquad Q = \sum_{j=1}^{m} Q_j$$

Then the contributions from each of the m emission grid squares are determined following a procedure similar to that for a single emission grid square.

In the third case, a small area source may be imbedded in a large area source. The emission rate of the latter source is divided into components for each covered square as described above. Then each square is considered as an area source with an emission rate equal to the sum of the component emission rates from the original area sources.

2.3.2 Concentration Algorithms

The urban area sources consist of fugitive dust, highway, residential, commercial and industrial emissions, and their inventories are generally not detailed enough to provide information on the source height and plume-release conditions such as plume velocity, temperature, building wakes, etc. Furthermore, there are no reliable methods to estimate the plume rise from these distributed sources. Therefore, their emissions are

generally assumed to be located at the ground-level (i.e., H=0) for simplicity. This assumption, however, may lead to calculation of large surface-concentrations, especially under light wind conditions when building wake-induced dispersion is less important and hot emissions from roof-top sources may have a rise comparable to the building height. The area-source concentration algorithms used in PEM-2 permit the user to specify a value of $H \geqq 0$ to represent the average effective height of emissions from the area sources in the inventory. This value of H is assumed to be constant for each concentration-averaging period.

The ground-level concentrations of the primary and secondary pollutants resulting from urban area source emissions in PEM-2 are computed by numerical integration of the corresponding point-source concentration algorithms. The urban area-source modeling techniques due to Gifford and Hanna (1970) are utilized in these computations. These techniques are based on the "narrow plume hypothesis," which postulates that the concentration at a receptor is influenced only by the distributed area sources located in a fairly narrow, plume-shaped upwind sector. This assumption allows one to ignore the lateral variation of concentration and the "end effects" due to the finite size of an area source grid; the concentration downwind of the center of the emission grid is then the same as that if the area source were infinitely wide in the crosswind direction.

We consider nine calculation grid squares (denoted by i=0, 1, 2, ----, 8), each with a receptor R_i located at its center. Figure 1 illustrates this schematically for the first five squares. The source emissions are assumed to be located at the center of the first square (i=0) upwind of the receptors. The emission rate of the primary pollutant from this single area

source is Q_1. Then the ground-level concentrations of the primary and secondary pollutants, C_{A1i} and C_{A2i} respectively, at the receptor R_i in the ith calculation grid square downwind are obtained, following Rao (1982), by integrating the point-source concentration algorithms as follows:

$$C_{A1i} = \frac{Q_1}{U}\int_{x_{1i}}^{x_{2i}} \frac{g'_{21}(x,z=0)}{L_z}\,dx \tag{5a}$$

$$C_{A2i} = \frac{Q_1}{U}\int_{x_{1i}}^{x_{2i}} \frac{g'_{22}(x,z=0)}{L_z}\,dx \tag{5b}$$

The nondimensional functions g'_{21} and g'_{22} are defined in Appendix A, and $L_z = \sqrt{2\pi}\,\sigma_z$; x_{1i} and x_{2i} are distances measured from the center of the first square (i=0) to the upwind and downwind edges, respectively, of the calculation grid square with the ith receptor (see Fig. 1); U is the surface wind speed input to the model if the effective height of emissions $H < 10$ m, or the adjusted wind speed of $H > 10$ m (see Section 2.5.2).

The relative concentrations, UC_{A1i}/Q_1 and UC_{A2i}/Q_1, determined from Eq. (5) are independent of the emission rates of the species (except for the ratio Q_2/Q_1 which appears in g'_{22}) and their values at the receptors in the nine downwind calculation grid squares are calculated only once for each scenario. These relative concentrations are then multiplied by the emission rate Q_1 of each area source and U^{-1} to obtain the contributions to the concentrations C_{A1} and C_{A2} at each of the nine affected receptors. Note that, for a given scenario, each area source will have the same spatial pattern of affected receptors downwind. The contributions of all area

sources affecting each receptor are summed to obtain the total concentration at that receptor.

In PEM-2, the integrations indicated in Eq. (5) are performed numerically by the trapezoidal rule together with Romberg's extrapolation method. Utilizing a maximum of 14 bisections of the interval (x_{1i}, x_{2i}), this method computes an approximation for the integral to within 1 percent relative accuracy between successive approximations.

2.3.3 Dispersion Parameters

The dispersion parameters, σ_z, used in Eq. (5) for area-source concentrations are the same as those used for point sources (see Section 2.2.3). These dispersion coefficients, given by Briggs (1973) and Gifford (1976), account for the effects of increased surface roughness and heat flux in the urban environment, and are most representative for z_o = 1 m and near-surface releases typical of the area sources.

2.4 RECEPTORS

2.4.1 Receptor Grid

PEM-2 calculates pollutant concentrations at each receptor in a rectilinear receptor array. A maximum of 2500 receptors may be used, with 50 columns and 50 rows. The spacing between each column and row is uniform, and is specified by the user. Receptors are located at the intersections of grid columns and rows. The grid spacing, number of columns, number of rows, and coordinates of the receptor at the southwest corner of the grid are used to define the grid.

Point and area sources need not necessarily be located within the grid boundaries. If area sources are included in the source inventory, the receptor grid spacing should be selected so that the smallest area source is of the same size as a grid square. An area source is positioned on the grid by specifying the coordinates of the southwest corner of the source. This corner should be located in the center of a receptor grid square, so that each square covered by the area source is centered on a receptor. For computations involving area sources, therefore, a calculation grid is defined with its grid squares the same size as receptor grid squares, but with a receptor located in the center of each calculation grid square. For details, see Section 2.3.1.

2.4.2 Automatic Grid Selection

PEM-2 has an optional subroutine which will automatically select a receptor grid for each scenario. The size and location of grids for different scenarios may differ since the selection of the receptor grid is based upon wind speed, wind direction, and atmospheric stability class.

Each source is examined sequentially. Two orthogonal axes are used with the origin located at the origin of the coordinate system for the point sources. The y axis is oriented in the north-south direction with positive values in the northerly direction. The x axis is oriented in the east-west direction with positive values in the easterly direction. Angle E is defined by

$$E = 90° - W$$

where W is the angle (measured relative to north) of the direction of the flow (see Fig. 3). The axes are then rotated through angle E such that the wind blows down the x axis. Negative values of E correspond to a clockwise rotation of coordinate axes; positive values correspond to a counter-clockwise rotation.

For each scenario, the grid is automatically selected so as to provide good coverage by receptors near the point of maximum concentration. This point is estimated from the Gaussian plume concentration algorithm without the pollutant removal or transformation mechanisms. For a point source, the downwind distance to the point of maximum concentration, x_{m2}, is calculated from the equation

$$\frac{1}{\sigma_y}\frac{d\sigma_y}{dx} = \frac{1}{\sigma_z}\frac{d\sigma_z}{dx}\left[\frac{H^2}{\sigma_z{}^2} - 1\right] \tag{6}$$

by the Newton-Raphson iterative method. In Eq. (6), H is the effective source height and σ_y and σ_z are the dispersion parameters given by Eq. (4). Equation (6) is derived by differentiating the expression for ground-level centerline concentration due to an elevated point source with respect to x, and equating it to zero.

Equation (6) is also used to determine x_{m1}, the point of maximum concentration using the physical stack height h_s instead of H. Then let

$$XTM(1) = XT + x_{m1}$$

$$XTM(2) = XT + x_{m2}$$

where XT is the x coordinate of the point source in the rotated coordinate system.

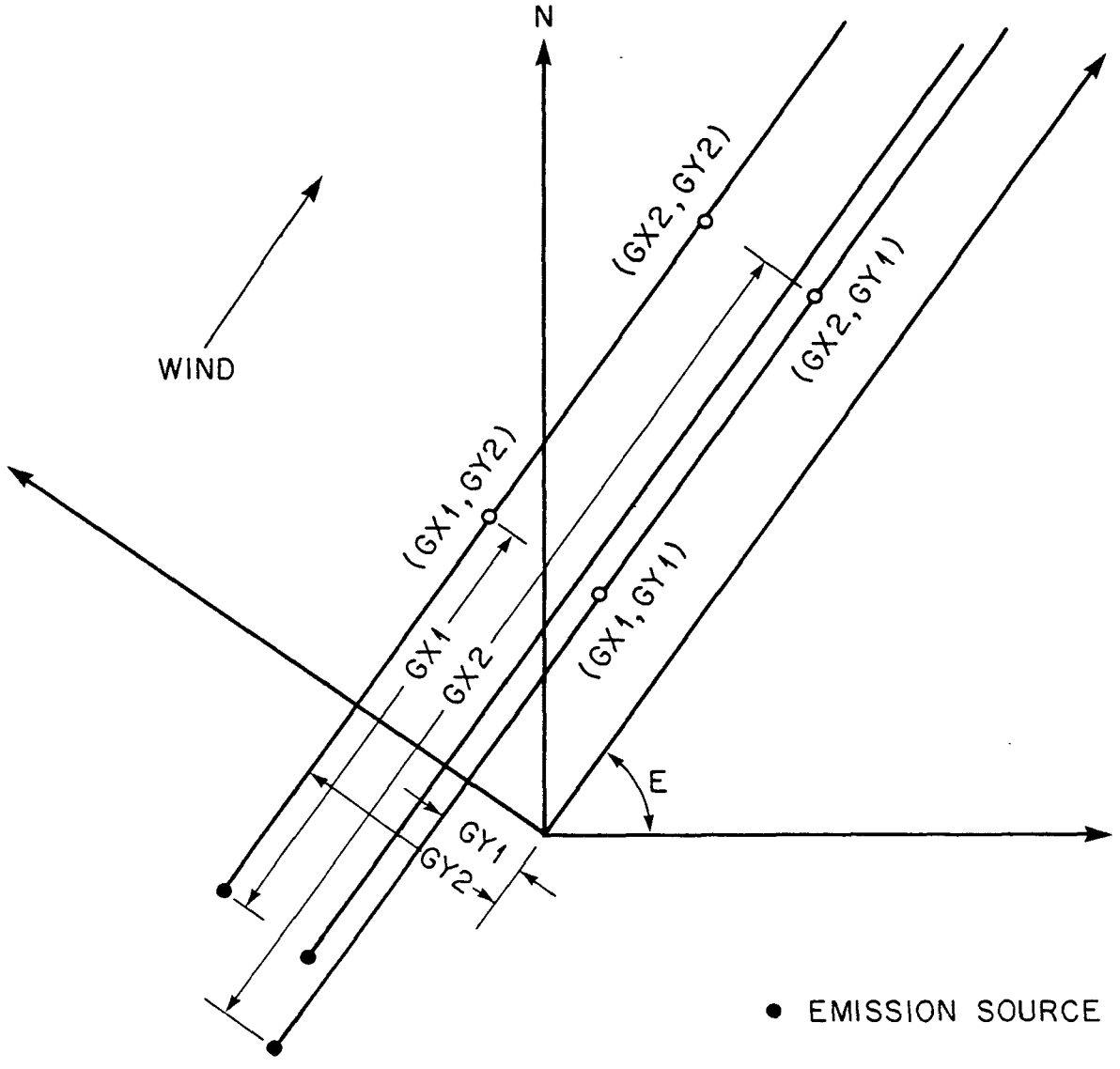

Figure 3. Points used for automatic selection of receptor grid by AUTGRD subroutine.

The largest value of XTM(2) for all point sources is GX2 and the smallest value of XTM(1) for all point sources is GX1. Let YT be the y coordinate of the point source in the rotated coordinate system. Then GY2 is the largest value YT for all point sources and GY1 is the smallest value of YT for all point sources. These points are illustrated in Fig. 3.

Next, the points (GX1, GY1), (GX2, GY1), (GX2, GY2) and (GX1, GY2) are rotated back to the original coordinate system. The largest of the four x values and the largest of the four y values are chosen for the coordinates of the northeast corner of the grid. The smallest of the four x values and the smallest of the four y values are chosen for the coordinates of the southwest corner of the grid.

Then XT is defined as the distance between the x coordinates of the grid corners and YT is the distance between the y coordinates of the grid corners. Let D_{max} be the larger of XT and YT. Then D_{max} is used to determine the number of columns and rows in the receptor grid and the grid spacing. If D_{max} is larger than 10 km, then the number of rows (or columns) is 50 and the grid spacing is XT/50 (or YT/50) km. If $5 < D_{max} < 10$ km, then a grid spacing of 0.2 km is used and the number of rows (or columns) is XT/0.2 (or YT/0.2). If $0.25 < D_{max} < 5$ km, then the number of rows (or columns) is 25, and the grid spacing is $D_{max}/25$. If $D_{max} < 0.25$ km, the grid spacing is 0.01 km, the smallest possible, and the number of rows (or columns) is XT/0.01 (or YT/0.01). A typical example of the receptor grid selected by the automatic grid option is illustrated in Fig. 4.

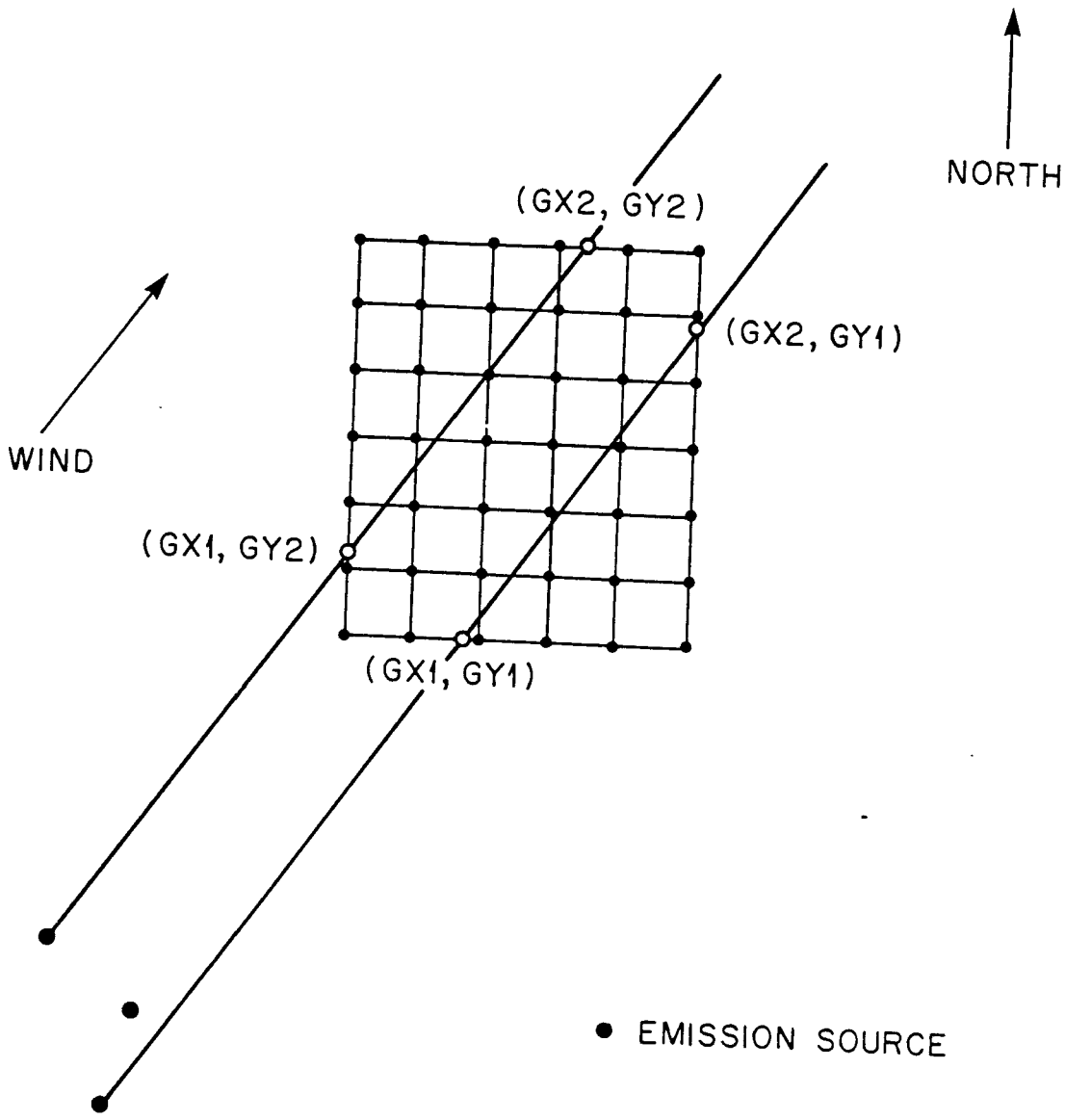

Figure 4. Example of a receptor grid selected by AUTGRD subroutine.

If the culpability list option is elected in PEM-2, the receptor grid is limited to 25 rows and 25 columns. In this case, the grid spacing is increased so that the number of rows (or columns) does not exceed 25.

The automatic grid selection procedure, outlined above, considers only point sources. Therefore, the chosen receptor grid may not be suitable if area sources are included in the inventory. Furthermore, the point of maximum concentration determined from Eq. (6) may be in error for problems which include significant deposition, sedimentation, and chemical decay or transformation. The optimum receptor grid in this case should be determined by trial and error, using the receptor grid defined by this automatic grid option as the first approximation.

2.5 METEOROLOGY

The meteorological data used as input to PEM-2 consist of the atmospheric stability class index, wind speed, wind direction, ambient temperature, mixing depth, and the potential temperature gradient in the elevated stable layer. This data set, which represents the mean atmospheric conditions over an hour, is called a scenario. The maximum number of scenarios in an averaging period is limited to 24, i.e., PEM-2 is designed to predict only short-term (1 to 24 hr) average concentrations. When available, quality-assured on-site meteorological data are preferable to the National Weather Service (NWS) data.

2.5.1 Atmospheric Stability

The Pasquill-Gifford atmospheric stability classes used in PEM-2 are defined in Table 4.

TABLE 4

Atmospheric Stability Classes

Stability Class Index	Atmospheric Stability Class	Description of Conditions
1	A	Extremely unstable
2	B	Moderately unstable
3	C	Slightly unstable
4	D	Neutral
5	E	Slightly stable
6	F	Moderately stable

The relationship between the atmospheric stability classes and wind speed, incoming solar radiation, and cloud cover is given by Turner (1970) and shown below in Table 5.

TABLE 5

Atmospheric Conditions Defining Stability Classes

	Day			Night	
Surface Wind Speed (at 10 meters),m/s	Incoming Solar Radiation Strong	Moderate	Slight	Thin overcast or $\geq$4/8 low clouds	$\leq$3/8 cloud
<2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

Class A is the most unstable, while class F is the most stable class considered in PEM-2. Night refers to the period from one hour before sunset to one hour after sunrise. Note that the neutral class, D, should be assumed for overcast conditions during day or night, regardless of wind speed.

2.5.2 Wind Speed

PEM-2 gives the user an option for specifying either an hourly mean wind speed or the wind speed class number. The latter is based on National Weather Service (NWS) classification. Any wind speed which lies in a given range is assigned that class number; PEM-2 uses a representative wind speed for each class as shown in Table 6.

TABLE 6

Wind Speed Classification

NWS Wind Speed Class	Wind Speed Range (knots)	Representative Wind Speed (m/s)
1	0 - 3	1.50
2	4 - 6	2.46
3	7 - 10	4.47
4	11 - 16	6.93
5	17 - 21	9.61
6	> 21	12.52

Wind speed near the surface generally increases with height. Most NWS wind speed measurements are taken at a height (h_o) of 10 m above the surface and are listed as "ground-level" wind speeds (U_o) in knots. Then the

wind speed (U) at the physical stack height (h_s) is determined as follows:

$$U = U_o \ (h_s/h_o)^p \tag{7}$$

The adjusted wind speed U is used (in meters/sec) in the plume rise calculations and the point-source concentration algorithms. Equation (7) is applied only when the stack height is greater than 10 m. The exponent p is a function of atmospheric stability class. The standard (default) values of p used in PEM-2 are shown in Table 7. For "ground-level" area source releases, the input wind speed (U_o) is used directly without any adjustment. If the effective height of area source emissions exceeds 10 m, then Eq. (7) is used to adjust the wind speed. For calm conditions (U_o = 0), the wind speed U_o is arbitrarily set to 1 m/s. However, since it is difficult to specify the wind direction under these conditions, it is better to remove "calm" hours from the input data.

TABLE 7

Values of Exponent p in Wind Speed Power Law

Atmospheric Stability Class	p
A = 1	0.15
B = 2	0.15
C = 3	0.20
D = 4	0.25
E = 5	0.30
F = 6	0.30

PEM-2 includes an option that allows the user to input site-specific values for h_o and/or p derived from local observations. The user should refer to Section 4.2.1 for details.

2.5.3 Wind Direction

By convention, wind direction is defined as the direction from which the wind is blowing. PEM-2 gives the user an option for specifying either an hourly mean wind direction, or the wind direction sector number based on the standard 16-point compass. Wind blowing from any angle in a 22.5° sector is assigned the number of that wind direction sector, and the wind direction is represented in the calculations by the median of that sector, as shown in Table 8.

TABLE 8

Wind Direction Sectors

Sector Number	Compass Point	Representative Wind Direction (deg)
1	N	0.0
2	NNE	22.5
3	NE	45.0
4	ENE	67.5
5	E	90.0
6	ESE	112.5
7	SE	135.0
8	SSE	157.5
9	S	180.0
10	SSW	202.5
11	SW	225.0
12	WSW	247.5
13	W	270.0
14	WNW	292.5
15	NW	315.0
16	NNW	337.5

PEM-2 also includes an option in which the user specifies the wind direction in degrees for the first of four sub-scenarios; for each succeeding sub-scenario, the wind direction is automatically shifted clockwise

by 90, 45, 30, 15, 10, or 5 degrees depending on the option number specified in the input, while keeping the other meteorological parameters constant. Details of these I/O control parameters are given in Section 4.2.1.

2.5.4 Mixing Depth

The turbulent mixing layer near the ground is frequently bounded by a layer of stable air aloft. The latter effectively limits vertical dispersion to the mixing layer. The height of the base of the inversion above the ground is called the mixing depth, L. The hourly mixing depths are specified in the input to PEM-2.

If vertical mixing is limited, pollutants emitted from a point source into the mixing layer will be trapped and, beyond some point downwind, will become uniformly mixed in the vertical. PEM-2 uses different sets of concentration algorithms for the (near-source) mixing region and the well-mixed region. The concentrations in the intermediate plume-trapping region are then obtained by interpolation as described in Section 2.2.1. The determination of the mixing regime and the algorithms to be used in the model depend on the atmospheric stability class, mixing depth, effective height of the source, and the downwind distance.

If the physical stack height exceeds the mixing depth, pollutants are emitted in the stable layer aloft; these pollutants will not be brought to the ground level and the source is neglected.

If the physical stack height is less than the mixing depth, but the effective source height H exceeds L, then the plume may or may not escape the mixing layer. A buoyant plume rising into a convectively or mechanically mixed layer may partially or completely penetrate the capping stable layer, depending on the stratification strength and elevation of the latter with respect to the plume.

The default penetration scheme in PEM-2 does not allow partial penetration of the elevated stable layer. For $H \leq L$, no penetration occurs; for $H > L$, complete penetration occurs and the source is ignored. However, PEM-2 includes optional new penetration schemes that consider the potential temperature gradient $\partial\theta_{ai}/\partial z$ in the elevated stable layer to estimate the extent of its penetration by a buoyancy-dominated plume in unstable/neutral atmosphere. The value of $\partial\theta_{ai}/\partial z$ is specified by the user in the meteorological data input to PEM-2; otherwise, a default value of 0.01°C/m (corresponding to an isothermal atmosphere) will be assumed in the calculations. The plume penetration schemes used in PEM-2 are discussed in detail in Appendix B.

SECTION 3

COMPUTER PROGRAM OVERVIEW

3.1 BASIS FOR PEM-2 PROGRAM

The PEM-2 computer program, listed in Appendix F, was developed by modifying the FORTRAN program of the Pollution Episodic Model (Rao and Stevens, 1982). The latter, in turn, was based on the computer program of the Texas Episodic Model Version 8 (TEM-8) and its Users' Guide (1979). TEM-8 uses the Gaussian plume concentration algorithms developed for non-reactive pollutants and a perfectly reflecting lower boundary. Chemical and physical depletion processes are therefore ignored, except for an option which allows a simple exponential decay of pollutant concentration with travel time. This method requires an accurate estimate of the pollutant's half-life.

In contrast, both PEM-2 and PEM explicitly account for dry deposition, gravitational settling, and a first-order transformation of two chemically-coupled gaseous or particulate pollutants in the concentration algorithms. The surface concentrations and deposition fluxes of both the primary pollutant (species-1 or reactant) as well as the secondary pollutant (species-2 or reaction product) are calculated. Thus, since PEM-2 accounts for these processes, the concentration algorithms used in PEM-2 and TEM-8 are different, though both models share essentially the same framework for calculations.

The PEM-2 model is developed from the PEM (Rao and Stevens, 1982) and the TEM-8 (Texas Air Control Board, 1979) with the following key modifications:

1. PEM-2 uses Briggs' (1973) urban dispersion parameters (based on the St. Louis diffusion data of McElroy and Pooler, 1968) for both point and area sources, whereas PEM and TEM-8 use power laws based on Pasquill-Gifford (PG) σ's for point sources and Gifford-Hanna (1970) σ_z's for area sources.

2. The number of atmospheric stability classes in PEM-2 are reduced to six, from seven in PEM and TEM-8, by combining the DD (neutral/day) and the DN (neutral/night) classes into a single D (neutral) class to conform with the current regulatory practice of the EPA.

3. For buoyancy-dominated plumes in unstable/neutral atmosphere, Briggs' (1984) new plume rise equations and plume penetration (of an elevated stable layer) schemes are included as optional features in PEM-2. On the other hand, PEM and TEM-8 use only the standard "all or none" criterion for determining plume penetration, and simulate inversions of various strengths by arbitrarily specifying an inversion penetration factor.

4. An option is provided in PEM-2 to use site-specific input values for the exponents of the wind-profile power law and anemometer height.

5. Concentrations from area source emissions (located at any effective height $H \geq 0$) are computed by numerical integration in PEM-2, while concentrations from area source emissions (assumed to be at ground-level) in PEM and TEM-8 are calculated from analytical concentration algorithms. The number of calculation grid squares used for each area source has been increased from 5 (in PEM and TEM-8) to 9 in PEM-2 to increase the calculated plume length and improve the model accuracy.

3.3 STRUCTURE OF THE PROGRAM

Figure 5 shows the structure of the PEM-2 computer program, its subroutines and functions. All input data to the model are read through subroutine INMOD. In order to calculate the relative concentrations of the species from area sources, the main program calls subroutine XINTEG to

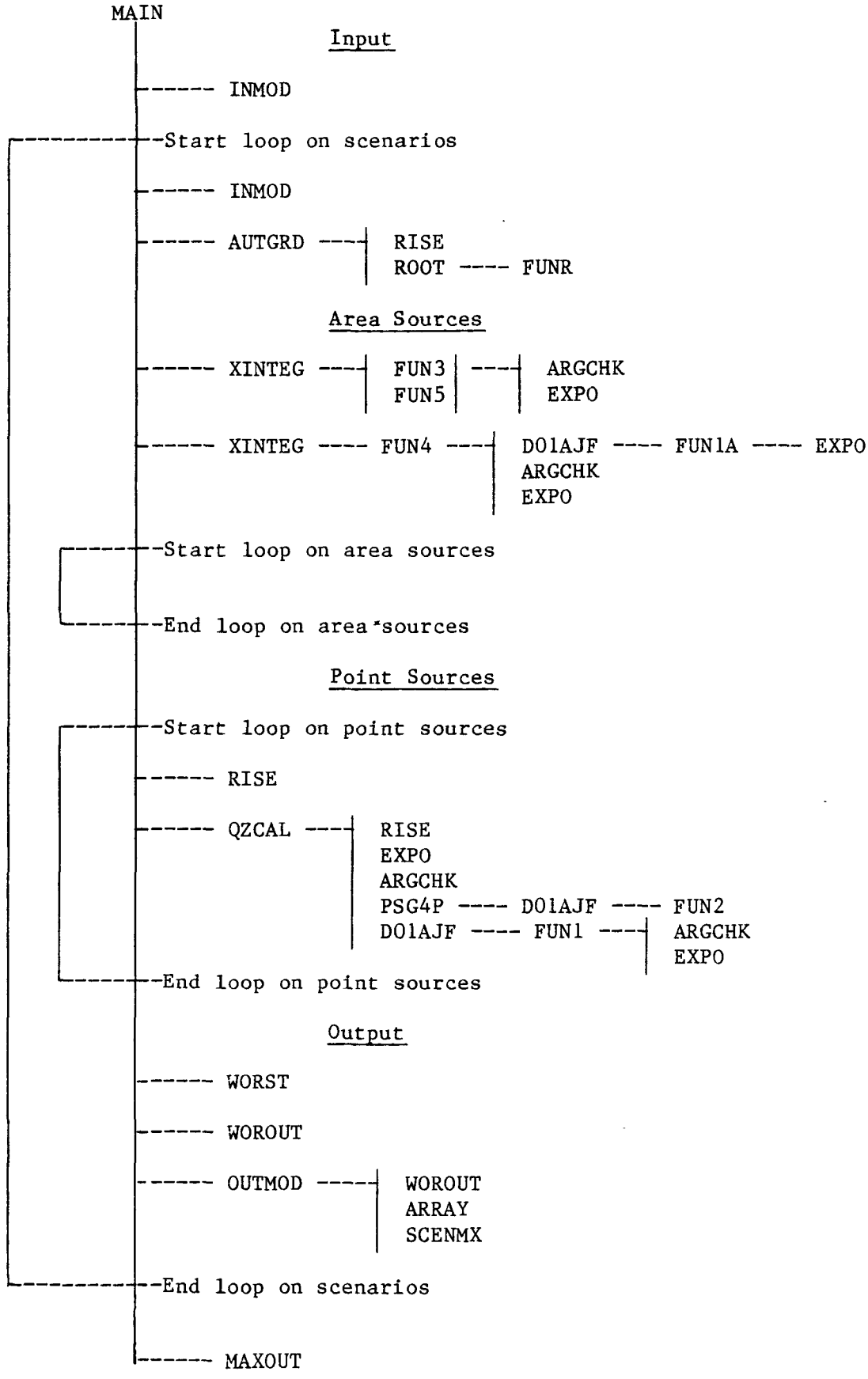

Figure 5. Structure of computer program.

perform the numerical integrations. For each scenario, these numerical integrations are done only once, and each area source will have the same spatial pattern of affected squares downwind. These relative concentrations are then multiplied with the effective emission rates of the area sources to obtain the contributions to the concentrations at each receptor. After the area source calculations are completed, the program starts point source calculations by calling subroutines RISE and QZCAL. The latter calculates the probability densities of vertical distributions of concentrations of the two pollutants using the appropriate algorithms. All output is printed in subroutine OUTMOD, which calls and uses other optional output routines. This procedure is repeated for all scenarios.

3.3 GENERAL FLOW OF THE PROGRAM

At the beginning of the run, PEM-2 reads in all input data, screens them, prints warning messages, and sets default values as necessary. All control parameters are listed and explained. Input data for meteorological conditions, area sources, and point sources are also listed. Some errors in input data may be serious enough to cause cancellation of the run; however, in general, PEM-2 attempts to recover from input errors and complete the run using default values. The program prints an appropriate message whenever it resets an important input parameter to a default value.

Inventories of area and point sources must include the locations of the sources on a receptor grid, their emission rates, the size for area sources, and stack parameters for point sources.

These inventories are used with sets of hourly meteorological data called scenarios. For each scenario, the concentration and surface deposition flux are calculated at each impacted receptor in the grid.

Output options are many and varied. Concentration and surface deposition flux may be presented in the form of lists, array maps, or records on tape. Other options include a culpability list of point sources, and information on plume rise and effective stack heights for each scenario. At the end of the averaging period, a list of receptors with the highest concentration for each pollutant may be printed. The details of these I/O options are given in Section 4. The calculation of the surface deposition fluxes of the pollutant species is discussed in Appendix C.

SECTION 4

PROGRAM USER'S GUIDE

4.1 SUMMARY OF PROGRAM INPUT

Control Parameters (7 cards)

Control parameters remain constant throughout the run. They specify 1) a title; 2) run options for time-averaging, and types of input and output, and technical options for use of stack-tip downwash algorithm, new plume rise equations and plume penetration schemes; 3) receptor grid coordinates and spacing; 4) deposition and settling velocities of pollutants and an option to calculate chemical transformation or decay at a given rate; 5) scaling factors for area source emissions and calibration coefficients to be applied to the calculated concentrations; 6) labels for the pollutants and calibrations; and 7) an option for using site-specific values for wind-profile exponents and anemometer height.

Scenario Parameters (1-24 cards)

Each card contains information for one scenario; i.e., the meteorological data for one hour. It includes atmospheric stability class, wind speed, wind direction, temperature, mixing height, and potential temperature gradient in the elevated stable layer above the mixing height.

Area Source Parameters (0-50 cards)

Each card contains information for one area source. It includes the location of the area source on the receptor grid, the size of the area source, and its emission rates.

A blank card must follow the last area source card to signal the end of the area source data.

Point Source Parameters (0-300 cards)

Each card contains information for one point source. It includes the location of the point source on the receptor grid; its emission rates; the stack parameters of height, diameter, plume velocity and temperature; and a label which identifies the point source.

A blank card must follow the last point source card to signal the end of the point source data.

4.2 DETAILS OF PROGRAM INPUT

4.2.1 Control Parameters (7 cards)

Card 1 : Title FORMAT (20A4)

Information identifying the run, which is printed at the top of each page of output. Up to 80 alphanumeric characters are allowed.

Card 2 : Input and output options FORMAT (18I4)

NTOPT Averaging time option

=1 One hour: Concentrations are calculated for each scenario. No averaging done.

=2 Twenty-four hours: Concentrations are calculated for exactly 24 scenarios and averaged.

=3 Variable (2 to 23 hours): Concentrations are calculated for a given number of scenarios and averaged.

The default value is NTOPT = 1 .

NWDOPT Wind direction input option

=0 The user will specify wind direction in degrees for each scenario.

=1 The user will specify a wind direction sector number (from 1 to 16) for each scenario.

=2-7 The user will specify wind direction in degrees for the first of four sub-scenarios. For each succeeding sub-scenario, the wind direction is automatically shifted clockwise by 90, 45, 30, 15, 10, or 5 degrees for option numbers 2, 3, 4, 5, 6, and 7, respectively. NWDOPT = 2-7 is not allowed with time-averaging, i.e., when NTOPT = 2 or 3 .

The default value is NWDOPT = 0 .

NWSOPT Wind speed input option

=0 The user will specify surface wind speed in meters/sec for each scenario.

=1 The user will specify a wind speed class number (from 1 to 6) for each scenario.

The default value is NWSOPT = 0 .

NWPOPT Wind-profile exponents input option

=0 The model uses the standard (default) values for the urban wind-profile exponents. The anemometer height for surface wind observations is assumed to be 10 m.

=1 The user will input site-specific values for wind-profile exponents and anemometer height on Card 7.

The default value is NWPOPT = 0 .

NSCEN Number of scenarios

=1-24 The number of sets of hourly meteorological data to be read and processed by the program. If NTOPT=2 is specified, then NSCEN must equal 24 . If NSCEN is not specified correctly, then either the input data file will be misread or the run will be terminated.

The default value is NSCEN = 1 .

NLIST Output option for printing lists of uncalibrated concentration and surface deposition flux, and calibrated concentration at each receptor in the grid.

=0 The lists are not printed.

=1 Lists of concentration and surface deposition flux are printed, for one or two pollutants, at grid receptors with uncalibrated concentrations of at least 1 microgram per cubic meter.
NLIST = 1 may not be used with the automatic windshift option (NWDOPT > 1) .

The default value is NLIST = 0 .

NARRAY Output option for array maps of calculated concentration and surface deposition flux at each receptor in the grid.

=0 No array maps are printed.

=1 Separate maps of uncalibrated concentration and surface deposition flux, and calibrated concentration are printed --- a total of three maps for each pollutant.

=2 Maps of uncalibrated concentration and surface deposition flux are printed --- two maps for each pollutant.

=3 Maps of calibrated concentration and surface deposition flux are printed --- two maps for each pollutant.

The default value is NARRAY = 0 .

NTAPE Tape output option for a list of both uncalibrated and calibrated concentrations and surface deposition fluxes at each receptor in the grid.

=0 The list is not written on tape.

=1 A list of concentrations and deposition fluxes is written on a separate output tape, one receptor per record. Control parameter INTER may be set to limit the number of receptors written on tape. The program checks the total number of records to be written; if the number is greater than 62500, a message is printed and NTAPE is set to zero.

NTAPE=1 may not be used with the automatic windshift option (NWDOPT > 1). NTAPE=1 may be used with NTOPT=1 to store the hourly concentrations, in order to calculate average concentrations externally for problems with highly variable emission, transformation, and deposition rates (see Section 1.3).

The default value is NTAPE = 0 .

NCSOPT Output option for a culpability list of the five point sources which contribute most to the total concentration calculated at each receptor.

=0 The culpability list is not printed.

=1 For each receptor in the grid, the program lists up to five point sources and the percentages of total concentration contributed by these sources. The total concentration and surface deposition flux at each receptor are also listed. This information is printed, for one or two pollutants, only at receptors with the highest contributions exceeding 1 microgram per cubic meter. NCSOPT=1 can be used only with NTOPT=1 . This option may not be used for more than one scenario with the automatic windshift option (NWDOPT>1). It also may not be used when the number of columns (LX) or the number of rows (LY) in the grid is greater than 25 .

The default value is NCSOPT = 0 .

NMAX Output option for listing the maximum concentration and surface deposition flux calculated for each pollutant.

=0 The lists are not printed.

=1 At the end of the run, for each scenario or averaging period, lists are printed to show the receptor which received the highest concentration and deposition flux for each pollutant.

The default value is NMAX = 0 .

NSTDWN Technical option for stack-tip downwash algorithm for point sources.

=0 The stack-tip downwash algorithm is used in the program to include the downwash effects.

=1 The downwash algorithm is not used.

The default value is NSTDWN = 0 .

NPRISE Technical option to use Briggs' new equations for maximum rise of buoyancy-dominated plumes from point sources.

=0 Standard Briggs' plume-rise equations are used for all stability classes.

=1 New equations are used for maximum plume rise of buoyancy-dominated plumes for stability classes A-D (unstable/neutral atmosphere).

The default value is NPRISE = 0 .

NINPEN Technical option to use new schemes for penetration of buoyancy-dominated plume above mixing height.

=0 Standard "all or none" criterion for plume penetration above mixing height is used.

=1 New schemes are used for buoyancy-dominated plume penetration of elevated stable layer for stability classes A-D (unstable/neutral atmosphere).

The default value is NINPEN = 0 .

INTER Output option for interval of receptors written on tape.

=N When the output option NTAPE=1 is selected, the value of INTER determines which receptors are written on the tape. When INTER is specified as integer N, every Nth receptor in each column and row is listed. Thus, if INTER=2, one fourth of the receptors will be listed; if INTER=5, one twenty-fifth will be listed. Effectively, an output grid is set up with "new" spacing equal to the value of INTER*GRID, and only those receptors on the "new" grid will be listed on the tape.

The default value is INTER = 1 .

NPRINT Output option for point source information.

=0 Input point source data is printed only at the beginning of each run.

=1 A list of input point source parameters and calculated plume rise information is printed for each scenario.

The default value is NPRINT = 0 .

INPTSC Input option for point source data.

=1 Point source data is read from the normal input stream (on cards, for example).

=2 Point source data is read from a disk file specified by the user.

The default value is INPTSC = 1 .

NGPR Gradual plume rise option for point sources.

=0 Gradual plume rise used close to point source(s).
=1 Final effective plume rise height used for all distances.

NBID Option to consider bouyancy induced dispersion (BID).

=0 BID is not used.
=1 BID is considered for elevated point sources.

Card 3 : Grid information FORMAT (2F10.0,2I10,3F10.0)

XRSWC The x, or east-west coordinate of receptor at the southwest corner of the grid, in kilometers.
The default value is XRSWC = 0.0 .

YRSWC The y, or north-south coordinate of receptor at the southwest corner of the grid, in kilometers.
The default value is YRSWC = 0.0 .

LX The number of columns of receptors in the grid. Allowable values are 1 to 50 .
The default value is LX = 1 .

LY The number of rows of receptors in the grid. Allowable values are 1 to 50 .
The default value is LY = 1 .

GRID Automatic grid option or grid spacing.

=0.0 The program designs the receptor grid for each scenario such that there is good receptorcoverage near the point of maximum concentration. For point sources, this location is determined from the Gaussian plume algorithm without deposition or transformation. For problems that include these removal mechanisms and area source emissions, therefore, this automatic grid may not be the optimum grid. This option cannot be used when NTOPT > 1 .

>0.0 The size of the spacing between columns and rows of receptors in the grid, in kilometers.
The default value is GRID = 0.0 .

DTDZ(1), DTDZ(2) The atmospheric potential temperature gradient for E and F stability classes, respectively, in deg. C/meter. These values are used in the plume

rise equations under stable conditions.
The default values are DTDZ(1) = 0.02 and
DTDZ(2) = 0.035 .

Card 4 : Pollutant deposition and chemical transformation parameters FORMAT (2I5, 6F10.0)

NPOL The number of pollutants (1 or 2)
The default value is NPOL = 1 .

ICT Chemical transformation or decay option.
=0 Transformation/decay of pollutant-1 is ignored.
=1 If NPOL = 1, a first-order chemical decay of the pollutant-1 is considered.
If NPOL = 2, a first-order chemical transformation of pollutant-1 to pollutant-2 is considered.
The default value is ICT = 0 .

VD1 Deposition velocity of pollutant-1, in cm/sec.

W1 Settling velocity of pollutant-1, in cm/sec.

VD2 Deposition velocity of pollutant-2, in cm/sec.

W2 Settling velocity of pollutant-2, in cm/sec.

The default values of W and VD for both species are zeros. If either W or VD is less than 0.01 cm/sec, then the value of that parameter is set to zero. This reduces computer run times and job costs without significantly altering the calculated concentrations.
In general, for deposition to occur, the settling velocity (W) should be less than or equal to the deposition velocity (VD). For gases and very small particles, W should be zero. For small particles, W should be less than VD. For particles of size d > 50 microns, W should equal VD.

XKT Chemical transformation or decay rate of pollutant-1 , in percent/hour. Allowable values are 0.1 to 100.0 ; input values outside this range are set to the nearer limit. For example, if XKT=0.0 is specified (when ICT=1), then the program prints a message and sets XKT=0.1 .

GAMMA The ratio of molecular weights of pollutant-2 (product) to pollutant-1 (reactant) in the chemical transformation (when ICT=1).
The default value is GAMMA = 0.0 .

Card 5 : Scaling and calibration FORMAT (7F10.0)

HAS The effective height of area source emissions in meters. Note that a single value is used to approximate the height of emissions from all urban area sources.
The default value is HAS = 0.0 .

ASCALE(1), ASCALE(2) Area source scaling factors for pollutants 1 and 2. All area source emission rates are multiplied by ASCALE(1) for pollutant-1 and by ASCALE(2) for pollutant-2. These factors may be utilized to scale the entire area source inventory to account for higher emission rates expected in future years (from an increased traffic volume, for example), or to convert the units of emission rates in the inventory to grams/sec.
The default values are ASCALE(1) = 1.0 and ASCALE(2) = 1.0 .

A(1), B(1) Coefficients used to calibrate the calculated concentration of pollutant-1.
The calibrated concentration, C* , is computed from the formula C* = A + B . C , where C is the uncalibrated concentration. The normal output units of the latter are micrograms per cubic meter. The calibration coefficients can be used to convert the units to percent allowable, parts per million, or any other convenient units.
The default values are A(1) = 0.0 and B(1) = 0.0 .

A(2), B(2) Coefficients used to calibrate the calculated concentration of pollutant-2.
The default values are A(2) = 0.0 and B(2) = 0.0 .

Card 6 : Labels FORMAT (3A4,7A4,3A4,7A4)

POLNAM(1) Name for pollutant-1
Up to 12 alphanumeric characters are allowed.

CALNAM(1) Label for calibrated values of concentration of pollutant-1, computed from calibration coefficients A(1) and B(1).
Up to 28 alphanumeric characters are allowed.

POLNAM(2) Name for pollutant-2
Up to 12 alphanumeric characters are allowed.

CALNAM(2) Label for calibrated values of concentration of pollutant-2, computed from calibration coefficients A(2) and B(2).
Up to 28 alphanumeric characters are allowed.

Defaults for all labels are blanks.

Card 7 (optional): Site-specific values of anemometer height and/or wind-profile exponents FORMAT (10F7.0)

HA — Anemometer height of wind speed measurement in meters. This is the height at which the surface wind speed is measured. The default value is HA = 10.0 .

HMIN — Wind speed held constant below this height in meters. Default value is HMIN = 10.

HMAX — Wind speed held constant above this height in meters. Default value is HMAX = 200.

UMIN — Wind speed not allowed less than this value (meters/s). Default value is UMIN = 1.0

P1(I), I=1,6 — Wind profile exponents derived from local observations for stability classes 1 to 6 . The default values are given in Section 2.5.2.

Note that site-specific values for anemometer height and/or wind-profile exponents can be specified only if the wind-profile option NWPOPT on Card 2 is specified as NWPOPT=1.

4.2.2 Scenario Parameters FORMAT(3I5,5F10.0)

One to 24 cards, each containing a set of meteorological data for one hour.

NSC — Atmospheric stability class number
Allowable values are 1 to 6 ; an input value outside that range will be set to the nearer limit.

NWS — Wind speed class
Allowable values are 1 to 6 ; an input value outside that range will be set to the nearer limit. Note that NWS is used only when the windspeed input option NWSOPT on Card 2 is specified as NWSOPT=1 .

NWD — Wind direction sector
Allowable values are 1 to 16 ; an input value outside that range will be set to the nearer limit. Note that NWD is used only when the wind direction input option NWDOPT on Card 2 is specified as NWDOPT=1 .

WS — Surface wind speed in meters/sec
This is assumed to be measured at a height of 10 meters unless a different value for anemometer height is specified on Card 7 above. Note that WS is used only when the wind speed input option NWSOPT on Card 2 is specified as NWSOPT = 0 . If WS=0.0 (calm) is specified

under this option, a message is printed and WS is set to 1.0 meter/sec.

WD Wind direction
The azimuthal angle in degrees of the direction from which the wind is blowing. Allowable values are 0.0 through 360.0 degrees. Note that WD is used only when the wind direction input option on Card 2 is specified as NWDOPT=0 or 2 through 7.
The default value is WD = 0.0, wind from the north.

TA Ambient temperature at 10 m height in deg. C.
The default value is TA = 0.0 .

HMIX Mixing height in meters
The height of the base of the inversion above the ground. This is also effectively the depth of the turbulent mixing layer.
The default value is HMIX = 9999.99 .

DTDZI Potential temperature gradient in the elevated stable layer above mixing height in deg. C/meter.
The default value is DTDZI = 0.01 .

4.2.3 Area Source Parameters FORMAT(5F10.0)

Zero to 50 cards, each containing parameters for one area source. A blank card must follow the last area source data card.

XA The x, or east-west, coordinate of southwest corner of the area source, in kilometers.
The default value is XA = 0.0 .

YA The y, or north-south, coordinate of southwest corner of the area source, in kilometers.
The default value is YA = 0.0 .

SIZE The length of a side of area source in meters.
The default value is SIZE = GRID*1000.0, the side of a receptor grid square in meters. If GRID=0.0 (i.e., automatic grid option is elected), then SIZE is arbitrarily set to 1.0 .

EA(1), EA(2) Emission rates for pollutants 1 and 2 in gms/sec.
Note that EA is not an emission rate per unit area; this is the emission rate of an equivalent point source located at the center of the area source.
The default values are EA(1) = 0.0
and EA(2) = 0.0 .

Note that area source inventory must be followed by a blank card to signal the end of area source data.

4.2.4 Point Source Parameters FORMAT(8F9.0, 2A4)

Zero to 300 cards, each containing parameters for one point source. A blank card must follow the last point source data card.

XP The x, or east-west, coordinate of point source, in kilometers.
The default value is XP = 0.0 .

YP The y, or north-south, coordinate of point source, in kilometers.
The default value is YP = 0.0 .

EP(1), EP(2) Emission rates for pollutants 1 and 2 in gms/sec.
The default values are EP(1) = 0.0 and EP(2) = 0.0 .

HP The physical height of the stack in meters.
The default value is HP = 0.0 .

DP The inside diameter of the stack-tip in meters. If DP=0.0 is specified, a message is printed and DP is set to 1.0E-4 meters.

VP The stack-exit velocity of plume in meters/sec.
The default value is VP = 0.0, which results in zero plume rise.

TP The stack-exit temperature of plume in deg. C.
The default value is TP = 0.0 , which usually results in a momentum-dominated plume rise.

NAME Label which identifies the point source. Up to eight alphanumeric characters may be used.
The default is blanks.

Note that the point source inventory is followed by a blank card to signal the end of the point source data.

4.3 GUIDE TO PROGRAM OUTPUT

PEM-2 has several output options which are outlined below. In order to avoid a large output, the user may select only the necessary options on Card 2.

NPRINT ---- Point source information

At the beginning of each scenario or sub-scenario*, for each point source, the output lists its coordinates on the receptor grid, emission rates, stack parameters, dominant influence (momentum or buoyancy) of plume rise, wind speed at physical stack height, maximum effective source height, and plume penetration fraction (see Appendix B).

NCSOPT --- Point source culpability list

At the end of each scenario or sub-scenario*, for each receptor in the grid, the five point sources which contributed most to the total concentration at that receptor are identified. For each receptor, the output includes the five point-source sequence numbers, the percentage of total concentration each of the five produced, and the total concentration and surface deposition flux at the receptor. This information is printed for one or two pollutants. To reduce the amount of output produced, only receptors with highest contributions exceeding 1 microgram per cubic meter are printed.

NLIST --- Concentration and surface deposition flux list

At the end of an averaging-period consisting of 1 to 24 scenarios, the uncalibrated concentration and deposition flux, as well as the calibrated concentration, of one or two pollutants are listed at each receptor in the grid. To reduce the amount of output produced, only receptors with uncalibrated concentrations of at least 1 microgram per cubic meter are listed.

NTAPE --- Concentration and surface deposition flux tape

At the end of the averaging-period, for each receptor in the grid, the calculated concentration and surface deposition flux are written on to a separate output tape. All records on the tape contain eighty alphanumeric characters. A separate record is written for every receptor in the grid, unless the interval parameter INTER has been specified as greater than

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*When the automatic windshift option is selected (NWDOPT > 1), a scenario is divided into four sub-scenarios, each with the same meteorological data except for the wind direction. The latter is shifted automatically by a given number of degrees for each sub-scenario.

one. The first record on the tape contains the title information given on Card 1 of the Control Parameter cards, written by FORMAT(20A4). Succeeding records contain the x,y coordinates of the receptor, values for concentration, deposition flux, calibrated concentration, and calibrated surface deposition flux for pollutant-1, followed by the values of these parameters for pollutant-2. These values are written by FORMAT(10F8.2).

NARRAY --- Array maps of concentration and surface deposition flux

At the end of each averaging-period, separate maps are printed for concentration and deposition flux for each pollutant. The values are printed at each receptor at its relative location on the grid to aid in visualization of the distribution of the pollutant.

The value specified for NARRAY determines which maps are printed. If NARRAY=1, separate maps of uncalibrated and calibrated concentrations, and uncalibrated deposition flux are printed (3 maps); if NARRAY=2, maps of uncalibrated concentration and deposition flux only are printed (2 maps); and if NARRAY=3, two maps of only the calibrated values are printed. Each map may require one, two, or four pages of output to display the entire grid, since each page can display values for up to 25 columns and 25 rows of the grid.

NMAX --- Maximum concentration and surface deposition flux

At the end of the last scenario or sub-scenario (if NTOPT=1) or at the end of the averaging period (if NTOPT>1), the receptors which receive the highest concentrations of pollutants-1 and 2, and the values of these concentrations, are listed. A second list gives the surface deposition fluxes at these receptors.

Note : The NCSOPT option can be used only with NTOPT=1; therefore, the output data printed with this option refer to hourly concentrations. When the NMAX option is used with NTOPT=1 and NSCEN > 1, the list of hourly maximum concentration and deposition flux values, and the receptors where they occur, is printed only after the last scenario has been processed.

When the time-averaging is selected (NTOPT=2 or 3), the output for option NPRINT is printed after each scenario, but the output for options NLIST, NTAPE, NARRAY, and NMAX is printed only after all scenarios of the averaging period have been processed. Thus, the concentrations and surface deposition fluxes printed in the output of the latter set of options represent the time-averaged values.

4.4 DISCUSSION OF I/O PARAMETERS

The PEM-2, designed to predict short-term (1 to 24 hr) average ground-level concentrations, assumes that emission rates are constant over the averaging period for NTOPT > 1. This may not be a good assumption for cases where the emissions are strongly time-dependent. For these cases, concentration estimates may be made for each hour with NTOPT = 1, using the appropriate emissions data and the mean meteorological conditions for that hour. Then concentrations for a period longer than an hour can be determined by averaging the hourly concentrations of that period. This can be done externally with minimal programming. The tape output option NTAPE=1 may be used to store the hourly concentration data.

The deposition and sedimentation velocities of the species and the chemical transformation rate are also assumed to be constant over the concentration-averaging period. If it is important to consider the diurnal variations of these parameters, a procedure similar to that described above for emissions can be used in concentration calculations.

The meteorological data input to PEM-2 consist of atmospheric stability class, wind speed, wind direction, temperature, mixing height, and the potential temperature gradient in the elevated stable layer. Each of these hourly data sets is called a scenario. For a given set-up of the receptor grid, the pattern of the impacted receptors downwind of a source depends primarily on the wind direction. For urban-planning or regulatory purposes, it may be necessary to investigate the effects of different wind directions on the calculated concentration patterns in the receptor grid. The PEM-2 has an option which divides each scenario into four sub-scenarios, each consisting of the same hourly meteorological data except

for the wind direction. When the user selects this automatic windshift option (i.e., NWDOPT > 1), the wind direction for only the first of the four sub-scenarios is specified by the user. For each succeeding sub-scenario, the wind direction is automatically shifted clockwise by a fixed number of degrees and the concentration calculations are repeated. The magnitude of this shift may be as large as 90° (for NWDOPT = 2), or as small as 5° (for NWDOPT = 7).

The calculated concentrations, C_i, of the species in the PEM-2 are given in $\mu g/m^3$; these are referred to as uncalibrated values, and represent only the contributions of the sources to the concentrations at the receptors. The user may add the background concentrations, or express the calculated concentrations in parts per million or percent allowable, by the formula

$$C_i^* = A_i + B_i \cdot C_i \ , \quad i = 1 \text{ or } 2,$$

where A_i and B_i are the user-specified calibration coefficients (with default values of zero), and C_i^* are the calibrated concentrations of the species. Depending on the value specified for NARRAY, the PEM-2 output may consist of array maps of either uncalibrated values or calibrated values, or both, of concentrations and surface deposition fluxes.

The culpability list output option, NCSOPT, is used for evaluation of control strategies. When this option is in effect, the five point sources which contributed most to the total concentration at each receptor are identified and their percent contributions are printed for each scenario. This option may be used for one or two pollutants, but only when the model calculates hourly concentrations with the time-averaging option NTOPT = 1.

Based on the number of pollutants (NPOL = 1 or 2) and the chemical transformation/decay option parameter (ICT = 0 or 1) specified in the input to the model, the PEM-2 program does one of the following:

1. If NPOL = 1 and ICT = 0 or 1, surface concentrations and deposition fluxes of one gaseous or particulate pollutant, with the given deposition and settling velocities, VD1 and W1 respectively, are calculated. If ICT = 1, then chemical decay of the pollutant is also considered if the decay rate XKT > 0. is given.

2. If NPOL = 2 and ICT = 0, surface concentrations and deposition fluxes of two different and uncoupled gaseous or particulate pollutant species with the given deposition and settling velocities, VD1 and W1 (for species-1) and VD2 and W2 (for species-2) respectively, are calculated. Emission rates for both species may be different. Chemical decay is not considered for either species even if XKT > 0.

3. If NPOL = 2 and ICT = 1, the two gaseous or particulate pollutant species are coupled through a first-order chemical transformation. The surface concentrations and deposition fluxes of both the primary pollutant (species-1 or reactant) as well as the secondary pollutant (species-2 or reaction product) are calculated. The chemical transformation rate (XKT > 0.) should be given. Non-zero direct emissions of the secondary pollutant from the point and/or area sources may also be specified as input for this case.

The specification of the deposition and gravitational settling velocities in the model is discussed in Appendix C.

4.5 EXAMPLE PROBLEMS

Three example problems are described below and the input data and output results of PEM-2 runs for these problems are shown in Appendix E to illustrate the use of the PEM-2 model.

Example 1

This problem deals only with area sources of all types. The first area source is of the same size as one receptor (or calculation) grid square. The second and third area sources are large and each covers several receptor grid squares. The fourth area source, covering one grid square, is imbedded in the third. All area source emissions are assumed to be at 10 m height. The receptor grid has 25 columns and 25 rows with a fine spacing of 1 km. Two chemically-coupled pollutants with a transformation rate of 1 percent per hour, and deposition velocities of VD1=1.0 and VD2=0.1 cm/sec, are calculated. Direct emission rates for pollutant-2 are specified to be one-tenth of the emission rates for pollutant-1. The input meteorology consists of three scenarios, each with the same wind direction but different wind speed and stability class. The output consists of array maps of 3-hour average surface concentrations and deposition fluxes, and a listing of the receptor with the highest average concentration of each pollutant.

Example 2(a)

This example considers two isolated point sources with tall stacks and very hot emissions to illustrate the new schemes in PEM-2 for buoyancy-dominated plume rise and plume penetration above mixing height. The direct emission rate of pollutant-2 is assumed to be 5 percent of the emission rate of pollutant-1. The chemical transformation rate is 10 percent/hour, and the deposition parameters are VD1=2.0, W1=0.0, VD2=0.5, and W2=0.2 cm/sec. The receptor grid has 25 columns and 25 rows, each spaced 2 km apart. Only one scenario is specified with stability class D, wind speed class 2, wind direction sector number 9, and a potential temperature gradient of 0.001 deg C/m above a mixing height of 550 m. The low values of the last two parameters are selected so that the plumes from the two stacks show significant penetration above the mixing height; the calculated plume penetration fractions (see Appendix B), printed by output option NPRINT (which gives the plume rise information), are 0.450 and 0.163 for stacks 1 and 2, respectively. Other output options selected print array maps of surface concentration and deposition flux for each pollutant, and the receptor with the highest concentrations for the hour.

Example 2(b)

The problem described above is repeated here, but with the standard (default) plume rise and penetration schemes in PEM-2; all of the other input-option parameters and data remain the same as given above, in order to facilitate comparison of the surface concentrations calculated by the "old" and "new" methods of accounting for the plume rise and penetration. The maximum effective source heights calculated by the two methods are about the same for stack 1, but the new penetration scheme (Example 2a) estimates that only 55 percent of the plume remains in the mixed layer and contributes to the concentrations, whereas the entire plume remains in the mixed layer in Example 2b. Therefore, for stack 1, the concentrations calculated in Example 2b are nearly twice as large as the corresponding values in Example 2a. For stack 2, the new schemes give a larger effective source height and estimate that only 84 percent of the plume remains within the mixed layer; therefore, the concentrations calculated in Example 2a are again smaller than in Example 2b.

This comparison clearly illustrates the need for the new plume rise equations which account for the differences between unstable and neutral conditions, and the new penetration schemes which consider partial plume penetration while accounting for the stratification in the elevated stable layer. In general, the standard "all or none" criterion predicts more occurences of plume penetration (which results in zero ground-level concentrations) than the new penetration schemes; the Examples given above are clearly designed to show the opposite in order to facilitate comparison.

Example 3

This problem deals with one large ground-level area source and three isolated point sources. The average direct emission rate of pollutant-2 is about 10 percent (or less) of the emission rate of pollutant-1. The chemical transformation rate is 5 percent/hour, and the deposition parameters are VD1=2.0, W1=0.0, VD2=0.2, and W2=0.0 cm/sec. The receptor grid has 25 columns and 25 rows with 1.5 km spacing. Six scenarios, representing moderately stable conditions, low temperatures, and variable wind speeds and directions, are specified. The input option NWPOPT=1 is elected; this requires the use of site-specific values for wind profile exponents and anemometer height given on Card 7. The atmospheric potential temperature gradients for E and F stability classes are specified as 0.015 and 0.030 deg C/m, respectively. The output includes array maps of 6-hour average concentrations and deposition fluxes for each pollutant, and the receptor with the highest concentrations for the averaging period.

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APPENDIX A

POINT SOURCE ALGORITHMS

The algorithms used in PEM-2 to calculate ground-level concentrations of gaseous or particulate pollutants released from an elevated continuous point source are derived by Rao (1982). These algorithms are based on a gradient-transfer model which describes the atmospheric transport, diffusion, dry deposition, sedimentation, and a first-order chemical transformation of pollutants. The analytical solutions of the model are expressed in terms of the empirical Gaussian plume dispersion parameters and extended to various atmospheric stability and mixing conditions. Details of the model and the solutions can be found in that reference. Here we only list the parameterized point source algorithms for the primary (reactant) and the secondary (reaction product) pollutants, denoted by subscripts 1 and 2, respectively.

For convenience, we adopt the following nondimensionalization scheme: All velocities are nondimensionalized by U, the constant mean wind speed. The horizontal downwind distance x and all vertical height quantities are nondimensionalized by $\sqrt{2}\ \sigma_z$; the chemical transformation time scale τ_c is nondimensionalized by $\sqrt{2}\ \sigma_z/U$. The horizontal crosswind distance y is nondimensionalized by $\sqrt{2}\ \sigma_y$. Thus, we define

$$\hat{V}_{d1} = V_{d1}/U \quad , \quad \hat{V}_{d2} = V_{d2}/U$$

$$\hat{W}_1 = W_1/U \quad , \quad \hat{W}_2 = W_2/U$$

$$\hat{V}_{11} = \hat{V}_{d1} - \hat{W}_1/2 \quad , \quad \hat{V}_{12} = \hat{V}_{d2} - \hat{W}_2/2$$

$$\hat{V}_{13} = \hat{V}_{11} - (\hat{W}_1 - \hat{W}_2)/2 \qquad \text{(A-1)}$$

$$\hat{V}_{21} = \hat{V}_{d1} - \hat{W}_1 \quad , \quad \hat{V}_{22} = \hat{V}_{d2} - \hat{W}_2$$

$$\hat{x} = x/\sqrt{2}\,\sigma_z \quad , \quad \hat{z} = z/\sqrt{2}\,\sigma_z$$

$$\hat{H} = H/\sqrt{2}\,\sigma_z \quad , \quad \hat{L} = L/\sqrt{2}\,\sigma_z$$

$$\hat{\tau}_c = \tau_c\, U/\sqrt{2}\,\sigma_z \quad , \quad \hat{y} = y/\sqrt{2}\,\sigma_z$$

where

H	= effective height of source
L	= height of the inversion lid or mixing depth
V_{d1} , V_{d2}	= dry deposition velocities of primary and secondary pollutants
W_1 , W_2	= gravitational settling velocities of primary and secondary pollutant particles
x, y, z	= horizontal downwind, horizontal crosswind, and vertical coordinates
σ_y , σ_z	= Gaussian dispersion parameters in y and z directions
τ_c	= characteristic time scale of first-order chemical transformation.

The nondimensional functions g'_{21} and g'_{22} used in Eq. (1) of Section 2.2.1 are now defined as follows:

$$g_1(\hat{x},\hat{y}) = \exp(-\hat{y}^2) \tag{A-2}$$

$$g'_{21}(\hat{x},0) = 2\exp(-\beta_1^2 - \hat{x}/\hat{\tau}_c) \cdot (1 - \alpha_1) \tag{A-3}$$

where

$$\alpha_1 = 2\sqrt{\pi}\,\hat{V}_{11}\,\hat{x}\;e^{\xi_1^2}\,\mathrm{erfc}\,\xi_1$$

$$\beta_1 = \hat{W}_1\,\hat{x} - \hat{H}$$

$$\xi_1 = \hat{H} + 2\,\hat{V}_{11}\,\hat{x} \tag{A-4}$$

$$g'_{22}(\hat{x},0) = 2\,e^{-\beta_2^2}\Big[(Q_2/Q_1 + \gamma)\cdot(1 - \alpha_2)$$

$$- \gamma\exp(-\hat{x}/\hat{\tau}_c)\cdot(1 - \alpha_3)$$

$$- \gamma\,2\sqrt{\pi}\,(\hat{V}_{21} - \hat{V}_{22})\,\hat{x}\cdot e^{\hat{H}^2}\cdot F_1(\hat{x},0)\Big] \tag{A-5}$$

where

$$\alpha_2 = 2\sqrt{\pi}\,\hat{V}_{12}\;\hat{x}\,e^{\xi_2^2}\,\mathrm{erfc}\,\xi_2$$

$$\alpha_3 = 2\sqrt{\pi}\,\hat{V}_{13}\;\hat{x}\,e^{\xi_3^2}\,\mathrm{erfc}\,\xi_3$$

$$\beta_2 = \hat{W}_2\,\hat{x} - \hat{H}$$

$$\xi_2 = \hat{H} + 2\,\hat{V}_{12}\,\hat{x}\;,\quad \xi_3 = \hat{H} + 2\,\hat{V}_{13}\,\hat{x} \tag{A-6}$$

and $$F_1(\hat{x},0) = \frac{1}{\pi} \int_0^1 \frac{1}{\sqrt{t(1-t)}} \exp\left(\frac{-\hat{H}^2}{t} - \frac{\hat{x}t}{\hat{\tau}_c} \right) \cdot$$

$$\left[1 - \sqrt{\pi}\,(\xi_4 - \hat{H}/\sqrt{t})\; e^{\xi_4^2} \operatorname{erfc} \xi_4 \right]$$

$$\left[1 - \sqrt{\pi}\,\xi_5\; e^{\xi_5^2} \operatorname{erfc} \xi_5 \right] dt \qquad \text{(A-7)}$$

where $$\xi_4 = \hat{H}/\sqrt{t} + 2\,\hat{V}_{13}\;\hat{x}\,\sqrt{t}$$

$$\xi_5 = 2\,\hat{V}_{12}\;\hat{x}\,\sqrt{1-t} \qquad \text{(A-8)}$$

In Eq. (A-5), γ is the ratio of molecular weight of the secondary pollutant to molecular weight of the primary pollutant, and Q_2/Q_1 is the corresponding ratio of emission rates of species. In Eq. (A-7), t is a parameterized dimensionless variable of integration with limits of 0 and 1.

The nondimensional functions g'_{41} and g'_{42} used in Eq. (2) of Section 2.2.1 are defined as follows:

<u>For $\hat{V}_{d1} \neq \hat{W}_1$ or $\hat{V}_{21} \neq 0$,</u>

$$g'_{41}(\hat{x}) = \exp(-\beta_1^2 - \hat{x}/\hat{\tau}_c) \left[(\hat{V}_{11}/\hat{V}_{21})\; e^{\xi_1^2} \operatorname{erfc} \xi_1 \right. \qquad \text{(A-9)}$$

$$\left. - (\hat{W}_1/2\hat{V}_{21})\; e^{\beta_1^2} \operatorname{erfc} \beta_1 \right]$$

where $\xi_1 = 2\,\hat{V}_{11}\,\hat{x}$ and $\beta_1 = \hat{W}_1\,\hat{x}$.

<u>For $\hat{V}_{d1} = \hat{W}_1$ or $\hat{V}_{21} = 0$,</u>

$$g'_{41}(\hat{x}) = \exp(-\xi_1^2 - \hat{x}/\hat{\tau}_c) \left[(1 + 2\,\xi_1^2)\, e^{\xi_1^2} \operatorname{erfc} \xi_1 - 2\,\xi_1/\sqrt{\pi} \right] \tag{A-10}$$

where $\xi_1 = 2\,\hat{V}_{11}\,\hat{x} = \hat{V}_{d1}\hat{x} = \hat{W}_1\,\hat{x}$.

<u>For $\hat{V}_{21} \neq 0$ and $\hat{V}_{22} \neq 0$,</u>

$$\begin{aligned} g'_{42}(\hat{x}) = e^{-\beta_2^2} \Bigg[& (Q_2/Q_1 + \gamma) \left\{ (\hat{V}_{12}/\hat{V}_{22})\, e^{\xi_2^2} \operatorname{erfc} \xi_2 - (\hat{W}_2/2\hat{V}_{22})\, e^{\beta_2^2} \operatorname{erfc} \beta_2 \right\} \\ & - \gamma\, e^{-\hat{x}/\hat{\tau}_c} \left\{ (\hat{V}_{13}/\hat{V}_{21})\, e^{\xi_3^2} \operatorname{erfc} \xi_3 - (\hat{W}_2/2\,\hat{V}_{21})\, e^{\beta_2^2} \operatorname{erfc} \beta_2 \right\} \\ & - \gamma\, 4\sqrt{\pi}\, (\hat{V}_{21} - \hat{V}_{22})\, \hat{x} \cdot F_2(\hat{x}) \Bigg] \end{aligned} \tag{A-11}$$

where $\xi_2 = 2\,\hat{V}_{12}\,\hat{x}$, $\beta_2 = \hat{W}_2\,\hat{x}$

$$\xi_3 = 2\,\hat{V}_{13}\,\hat{x}\ , \quad \hat{V}_{13} = \hat{V}_{11} - (\hat{W}_1 - \hat{W}_2)/2 \tag{A-12}$$

$$F_2(\hat{x}) = \frac{1}{2\pi}\int_o^1 \frac{1}{\sqrt{t}} \exp(-\hat{x}t/\hat{\tau}_c) \left[1 - \sqrt{\pi}\, \xi_4\, e^{\xi_4^2} \operatorname{erfc} \xi_4 \right] \cdot$$

$$\left[(\hat{V}_{12}/\hat{V}_{22})\ e^{\xi_5^2} \operatorname{erfc} \xi_5 - (\hat{W}_2/2\hat{V}_{22})\ e^{\xi_6^2} \operatorname{erfc} \xi_6 \right] dt, \qquad \text{(A-13)}$$

where $\xi_4 = \xi_3 \sqrt{t}$, $\xi_5 = \xi_2 \sqrt{1-t}$, $\xi_6 = \beta_2 \sqrt{1-t}$ (A-14)

<u>For $\hat{V}_{21} \neq 0$ and $\hat{V}_{22} = 0$,</u>

$$g'_{42}(\hat{x}) = e^{-\xi_2^2} \left[(Q_2/Q_1 + \gamma) \left\{ (1 + 2\,\xi_2^2)\, e^{\xi_2^2} \operatorname{erfc} \xi_2 - 2\,\xi_2/\sqrt{\pi} \right\} \right.$$

$$- \gamma\, e^{-\hat{x}/\hat{\tau}_c} \left\{ (\hat{V}_{13}/\hat{V}_{21})\, e^{\xi_3^2} \operatorname{erfc} \xi_3 - (\hat{W}_2/2\hat{V}_{21})\, e^{\xi_2^2} \operatorname{erfc} \xi_2 \right\}$$

$$\left. - \gamma\, 4\sqrt{\pi}\, \hat{V}_{21}\, \hat{x} \cdot F_2(\hat{x}) \right] \qquad \text{(A-15)}$$

where $\xi_2 = 2\,\hat{V}_{12}\,\hat{x} = \hat{V}_{d2}\,\hat{x} = \hat{W}_2\,\hat{x} = \beta_2$, $\xi_3 = 2\,\hat{V}_{13}\,\hat{x}$

$$F_2(\hat{x}) = \frac{1}{2\pi}\int_o^1 \frac{1}{\sqrt{t}} \exp(-\hat{x}t/\hat{\tau}_c) \left[1 - \sqrt{\pi}\, \xi_4\, e^{\xi_4^2} \operatorname{erfc} \xi_4 \right] \cdot$$

$$\left[(1 + 2\,\xi_5^2)\, e^{\xi_5^2} \operatorname{erfc} \xi_5 - 2\,\xi_5/\sqrt{\pi} \right] dt, \qquad \text{(A-16)}$$

with $\xi_4 = \xi_3 \sqrt{t}$, $\xi_5 = \xi_2 \sqrt{1-t}$.

For $\hat{V}_{21} = 0$ and $\hat{V}_{22} \neq 0$,

$$g'_{42}(\hat{x}) = e^{-\xi_3^2} \Bigg[(Q_2/Q_1 + \gamma) \left\{ (\hat{V}_{12}/\hat{V}_{22})\, e^{\xi_2^2} \operatorname{erfc} \xi_2 - (\hat{W}_2/2\hat{V}_{22})\, e^{\xi_3^2} \operatorname{erfc} \xi_3 \right\}$$

$$- \gamma\, e^{-\hat{x}/\hat{\tau}_c} \left\{ (1 + 2\,\xi_3^2)\, e^{\xi_3^2} \operatorname{erfc} \xi_3 - 2\,\xi_3/\sqrt{\pi} \right\}$$

$$+ \gamma\, 4\sqrt{\pi}\, \hat{V}_{22}\, \hat{x} \cdot F_2(\hat{x}) \Bigg] \qquad \text{(A-17)}$$

where $\xi_2 = 2\,\hat{V}_{12}\,\hat{x}$, $\xi_3 = 2\,\hat{V}_{13}\,\hat{x} = \hat{W}_2\,\hat{x} = \beta_2$,

and $F_2(\hat{x})$ is given by Eq. (A-13).

For $\hat{V}_{21} = 0$ and $\hat{V}_{22} = 0$,

$$g'_{42}(\hat{x}) = \left[Q_2/Q_1 + \gamma\,(1 - e^{-\hat{x}/\hat{\tau}_c}) \right] \cdot$$

$$e^{-\xi_2^2} \left\{ (1 + 2\,\xi_2^2)\, e^{\xi_2^2} \operatorname{erfc} \xi_2 - 2\,\xi_2/\sqrt{\pi} \right\} \qquad \text{(A-18)}$$

where $\xi_2 = \hat{W}_2\,\hat{x} = \beta_2$.

In Eqs. (A-7), (A-13), and (A-16), t is a parameterized integration variable. The integrand functions in these equations have singularities at the end-points t=0 and t=1 of the integration domain it t. Because of their complexity, these integrations cannot be carried out analytically; therefore, they should be evaluated by numerical integration to a sufficiently high degree of accuracy.

A computer-library subroutine named D01AJF, developed by the Numerical Algorithms Group (NAG), is utilized in PEM-2 for the numerical integration. This general purpose integrator routine, which is capable of handling the singularities, has been selected because of its accuracy and applicability. It estimates the value of a definite integral of an externally defined function over a finite range to a specified absolute or relative accuracy, using Gauss-Kronrod rules in an adaptive strategy with extrapolation. Further details of this subroutine can be found in Appendix D.

In the limit, when $V_{di} = W_i = 0$ and τ_c and ∞, the algorithms for g'_{21}, g'_{22}, g'_{41}, and g'_{42} (defined above) reduce to the familiar Gaussian-plume diffusion algorithms currently used in EPA air quality models. Thus the new algorithms given in this section may be though of as extensions of the latter to include deposition, sedimentation, and chemical transformation.

It should be noted that the algorithms for g'_{21} and g'_{22} are also used in Eq. (5) of Section 2.3.2 to calculate ground-level concentrations from area sources.

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APPENDIX B

PLUME RISE EQUATIONS AND PLUME PENETRATION METHODS

The various optional schemes used in PEM-2 for treatment of the stack-plume downwash, plume rise (including criteria for the crossover between momentum and buoyancy), and plume penetration of elevated stable layers are briefly described and the equations listed here. For further information, the user should consult the references cited.

Stack Downwash

PEM-2 provides a default option (NSTDWN=0) to account for the stack-tip downwash of the plume, following Briggs (1973), as follows:

$$h_s' = h_s + 2\,(R - 1.5)\,d \;, \quad \text{for } R < 1.5$$

$$h_s' = h_s \;, \quad \text{for } R \geqq 1.5 \qquad \text{(B-1)}$$

where $R = V_s/U$ and $h_s' \geqq 0$ is the "reduced" physical stack height. The various symbols are defined below. If the user specifies NSTDWN=1, the downwash correction is not used.

Plume Rise

The plume rise is estimated using Briggs' (1969, 1971) standard equations if the default option NPRISE=0 is used in PEM-2. There are four different situations for plume rise, and the corresponding equations can be written as follows:

1) For a buoyancy-dominated plume in unstable/neutral atmosphere,

$$\Delta h(x) = 1.6\ F_b^{1/3}\ x^{2/3}\ U^{-1}\ ,\ \text{for } x < x_{max} \tag{B-2}$$

and

$$\Delta h = 1.6\ F_b^{1/3}\ x_{max}^{2/3}\ U^{-1}\ ,\ \text{for } x \geqq x_{max} \tag{B-3}$$

where $x_{max} = 49\ F_b^{5/8}$, for $F_b < 55$

and $x_{max} = 119\ F_b^{2/5}$, for $F_b \geqq 55$ (B-4)

Note that by substituting (B-4) in (B-3), the maximum plume rise can also be expressed as

$$\Delta h = 21.425\ F_b^{3/4}\ U^{-1}\ ,\ \text{for } F_b < 55$$

and $\Delta h = 38.71\ F_b^{3/5}\ U^{-1}$, for $F_b \geqq 55$ (B-5)

2) For a momentum-dominated plume in unstable/neutral atmosphere,

$$\Delta h(x) = 1.89\ [R^2 d/(R+3)]^{2/3}\ x^{1/3}\ ,\ \text{for } x < x_{max} \tag{B-6}$$

and $$\Delta h = 3\ R\ d\ ,\ \text{for}\ x \geqq x_{max} \tag{B-7}$$

where $$x_{max} = 4d(R+3)^2/R \quad \text{and} \quad R = V_s/U \tag{B-8}$$

3) For a buoyancy-dominated plume in stable atmosphere,

$$\Delta h(x) = 1.6\ F_b^{1/3}\ x^{2/3}\ U^{-1}\ ,\ \text{for}\ x < x_{max} \tag{B-9}$$

and $$\Delta h = 2.6\ (F_b/U\ s)^{1/3}\ ,\ \text{for}\ x \geqq x_{max} \tag{B-10}$$

where $$x_{max} = 2.0715\ U\ s^{-1/2} \tag{B-11}$$

and $$s = (g/T_a)\ \partial\theta_a/\partial z \tag{B-12}$$

In (B-12), $\partial\theta_a/\partial z > 0$ is the vertical gradient of potential temperature in stable atmosphere. Its value may be specified by the user; otherwise, PEM-2 uses the default values of 0.02 and 0.035°K/m for E and F stability classes, respectively.

4) For a momentum-dominated plume in stable atmosphere,

$$\Delta h = 1.5\ (F_m/U)^{1/3}\ s^{-1/6} \tag{B-13}$$

and $$x_{max} = 0$$

For this case, there is no expression given for $\Delta h(x)$ since (B-13) is assumed to apply for all values of x. The smaller of the two Δh values calculated from (B-7) and (B-13) is taken as the final plume rise in this case.

After calculating the maximum plume rise from one of the equations given above, the effective source height can be obtained from

$$H = h_s' + \Delta h \tag{B-14}$$

The variables used in the equations listed above are defined here:

$$F_b = 0.25\ (g/T_s)\ V_s\ d^2\ \Delta T \tag{B-15}$$

= plume buoyancy flux at stack exit, m^4/s^3

$$F_m = 0.25\ (T_a/T_s)\ V_s^2\ d^2 \tag{B-16}$$

= plume momentum flux at stack exit, m^4/s^2

d = inside diameter of stack-tip, m

g = acceleration due to gravity, 9.8 m/s^2

h_s = physical stack height, m

h_s' = "reduced" physical stack height for downwash cases, m

H = effective source height, m

s = stability parameter, s^{-2}

T_a = atmospheric temperature, °K

T_s = plume temperature at stack exit, °K

U = mean wind speed at physical stack height, m/s

V_s = plume velocity at stack exit, m/s

x = downwind distance from stack, m

x_{max} = downwind distance at maximum plume rise, m

$\Delta h(x)$ = distance-dependent plume rise, m

Δh = maximum or final plume rise, m

$\Delta T = T_s - T_a$, plume temperature excess, °K

Crossover Between Momentum and Buoyancy

In order to properly use the plume rise equations given above, one should know whether the plume is dominated by momentum or buoyancy. This determination is generally based on the crossover temperature difference, $(\Delta T)_c$. Analytic expressions for $(\Delta T)_c$ can be derived, for given atmospheric conditions, by setting the maximum plume rise equation for the buoyancy-dominated plume equal to the corresponding equation for the momentum-dominated plume.

For unstable/neutral atmosphere, equating (B-5) to (B-7), we obtain the expressions

$$(\Delta T)_c = .02964\ T_s\ V_s^{1/3}\ d^{-2/3},\ \text{for } F_b < 55 \qquad \text{(B-17)}$$

and

$$(\Delta T)_c = .00575\ T_s\ V_s^{2/3}\ d^{-1/3},\ \text{for } F_b \geqq 55 \qquad \text{(B-18)}$$

For stable atmosphere, equating (B-10) to (B-13), we obtain the expression

$$(\Delta T)_c = .01957\ T_a\ V_s\ s^{1/2} \qquad \text{(B-19)}$$

For any given atmospheric stability, the plume is assumed to be buoyancy-dominated if $T_s > T_a$ and $\Delta T = T_s - T_a$ exceeds the crossover temperature difference $(\Delta T)_c$ calculated from the appropriate expression given above. If $T_s \leqq T_a$ or if $\Delta T \leqq (\Delta T)_c$, the plume is assumed to be momentum-dominated.

From (B-15), (B-17) and (B-18), the crossover criteria for unstable/neutral atmosphere may also be expressed in terms of the crossover plume-buoyancy flux, $(F_b)_c$, as follows:

$$(F_b)_c = .0727\ (V_s d)^{4/3}\ ,\ \text{for } F_b < 55 \tag{B-20}$$

$$(F_b)_c = .0141\ (V_s d)^{5/3}\ ,\ \text{for } F_b \geqq 55 \tag{B-21}$$

If $F_b > 0$ and $F_b > (F_b)_c$, then the plume is buoyancy-dominated; otherwise, it is momentum-dominated.

Similarly, from (B-12) and (B-19), the crossover criteria for stable conditions can be expressed in terms of the crossover plume velocity, $(V_s)_c$, as follows:

$$\begin{aligned} (V_s)_c &= 115.28\ \Delta T/T_a^{1/2} \quad \text{for E-stability} \\ (V_s)_c &= 87.14\ \Delta T/T_a^{1/2} \quad \text{for F-stability} \end{aligned} \tag{B-22}$$

The default values of 0.02 and 0.035°K/m for E and F stability classes, respectively, are assumed for $\partial\theta_a/\partial z$ in the above expressions. If the values specified by the user are significantly different, then the following general expression may be utilized:

$$(V_s)_c = 16.30\ \Delta T/(T_a\ \partial\theta_a/\partial z)^{1/2} \tag{B-23}$$

If $(V_s)_c > 0$ and $V_s < (V_s)_c$, then the plume is buoyancy-dominated; otherwise, it is momentum-dominated.

New Plume Rise Equations

For a buoyancy-dominated plume, the maximum plume rise given by (B-5) compromises substantial differences between unstable (convective turbulence) and neutral (mechanical turbulence) atmospheric conditions. The inverse

dependence of final plume rise on wind speed in (B-5) is rather simplistic, and the equations may seriously overpredict Δh for low-level sources at high wind speeds.

PEM-2 provides an option (NPRISE=1) to use Briggs' (1975, 1984) new equations to estimate the maximum rise of a buoyancy-dominated plume in unstable/neutral atmosphere. The new plume-rise equations show a weaker dependence of Δh on U in unstable conditions and a considerably stronger dependence on U in neutral conditions. These equations, which contain the minimum essential physics with the maximum allowable simplifications, can be written as follows:

For unstable atmosphere,

$$\Delta h = 30\ (F_b/U)^{3/5}\ ,\ \text{for } x \geqq x_{max} \tag{B-24}$$

where

$$x_{max} = 81.2\ F_b^{2/5}\ U^{3/5} \tag{B-25}$$

For neutral atmosphere,

$$\Delta h = 24\ (F_b/U^3)^{3/5}\ (h_s' + 200\ F_b/U^3)^{2/5}\ ,\ \text{for } x \geqq x_{max} \tag{B-26}$$

where

$$x_{max} = 58.1\ (F_b/U^3)^{2/5}\ (h_s' + 200\ F_b/U^3)^{3/5} \tag{B-27}$$

In PEM-2, for unstable/neutral conditions, Δh is evaluated from both (B-24) and (B-26), and the lower of these two values is selected as the maximum buoyancy rise of the plume. Generally, (B-24) gives the lower Δh value for low wind speeds, and (B-26) gives the lower value for high wind speeds. The maximum buoyancy rise thus determined is then compared with the maximum momentum rise of the plume evaluated from (B-7), and the higher of these two values is selected as the maximum plume rise. The

distance to the maximum plume rise, x_{max}, is then obtained from one of the equations (B-8), (B-25), and (B-27) that is appropriate for the selected final plume rise. For $x < x_{max}$, the distance-dependent plume rise is determined from (B-2), as before. This procedure was suggested by Turner (1985).

Plume Penetration of Elevated Stable Layer

The daytime turbulent mixed layer with a near-adiabatic lapse rate above the ground is frequently bounded by a thick layer of stably-stratified air aloft. This situation also occurs in the marine inversion layer in some coastal areas. The elevated stable layer then effectively limits vertical dispersion to the mixed layer of depth L. A buoyant plume rising into a convectively or mechanically mixed layer may partially or completely penetrate the capping stable layer, depending on the stratification strength and elevation of the latter with respect to the plume.

The default penetration-option (NINPEN=0) in PEM-2 does not consider partial penetration of the elevated stable layer. If the maximum effective source height, $H = h_s' + \Delta h$, exceeds the mixing depth L, then the pollutants are assumed to be emitted into the stable layer aloft; these pollutants will not be brought to the ground and, therefore, the source is ignored. If $H \leq L$, then the plume is assumed to be trapped within the mixed layer with no ability to penetrate the stable layer aloft. This treatment, which assumes either complete penetration of the elevated stable layer or no penetration at all, is similar to that used in EPA air quality models such as CRSTER.

PEM-2 provides an option (NINPEN=1) to use new penetration schemes that allow consideration of the strength of stratification of the elevated stable layer in estimating the extent of its penetration by a buoyancy-dominated plume in unstable/neutral atmosphere. These schemes, based on the work of Briggs (1975, 1984), Weil and Brower (1982), Turner (1985), and others, are briefly described below.

For a buoyant bent-over plume, the penetration criteria are based on the heights of the upper and lower edges of the plume at final rise, relative to the stable layer height, z_i', above the stack:

$$z_i' = L - h_s \tag{B-28}$$

Based on field observations, Briggs approximated the heights (above the stack) of the upper and lower edges of the bent-over plume by 1.5 Δh and 0.5 Δh, respectively, where Δh is the final rise of the plume. Penetration commences only when the upper edge of the plume is at the top of the mixed layer, i.e., $1.5\ \Delta h = z_i'$ or $\Delta h = (2/3)\ z_i'$. Therefore, the minimum effective plume centerline height necessary to consider penetration is given by

$$H_{pen} = h_s + (2/3)\ z_i' \tag{B-29}$$

where H_{pen} is referred to, hence, as the penetration height. If the effective source height, H, estimated from the standard or new plume-rise formulas given above, is less than H_{pen}, then no penetration occurs. If $H \geq H_{pen}$, then the fraction of the plume that penetrates the elevated stable layer is computed as given below.

Following Briggs, we define the plume penetration fraction, P, as the ratio of the depth of the plume above the elevated stable layer to the total plume depth:

$$P = (1.5\ \Delta h - z_i')/(1.5\ \Delta h - 0.5\ \Delta h) = 1.5 - z_i'/\Delta h \qquad \text{(B-30)}$$

As a simple and conservative approach to estimate the final plume rise, Briggs assumed that the mixed layer is stably-stratified with the same atmospheric potential temperature gradient, $\partial\theta_{ai}/\partial z$, as that in the elevated stable layer. Thus Δh in (B-30) is estimated from an expression similar to (B-10) for a buoyancy-dominated plume in stable atmosphere:

$$\Delta h = 2.6(F_b/U\ s_i)^{1/3} \qquad \text{(B-31)}$$

where

$$s_i = (g/T_a)\ \partial\theta_{ai}/\partial z \qquad \text{(B-32)}$$

The value of the atmospheric potential temperature gradient in the elevated stable layer is specified by the user in PEM-2; if it is not specified, a default value of 0.01°C/m (corresponding to an isothermal atmosphere) will be assumed by the model. This approach is conservative since the plume rise thus estimated will be much lower than that computed using a near-adiabatic lapse rate which is appropriate for the mixed layer.

The plume penetration fraction P is calculated from (B-30) and (B-31) such that $0 \leqq P \leqq 1$. No penetration (P=0) is assumed to occur when the plume upper edge is at or below the top of the mixed layer, i.e., $\Delta h \leqq (2/3)z_i'$. Complete penetration (P=1) occurs when the lower edge of the plume is at or above the top of the mixed layer, i.e., $\Delta h \geqq 2z_i'$. Partial penetration ($0 < P < 1$) occurs for $0.5\ \Delta h < z_i' < 1.5\ \Delta h$.

In PEM-2, we assume that only the fraction (1-P) of the plume material remaining within the mixed layer contributes to the ground-level concentrations (GLC); essentially, the fraction P of the plume material is lost. The effective source strength, Q_{ek}, is then given by

$$Q_{ek} = (1-P)\ Q_k\ , \quad k = 1,2 \tag{B-33}$$

where Q_k is the emission rate of species-k from the stack. In the concentration algorithms, the effective source height H represents only the height of the centerline of the plume, and not the heights of its upper and lower edges, when the plume is within the mixed layer. For partial penetration cases, therefore, a new effective source height (H_e) should be determined for the fraction of the plume remaining within the mixed layer. First, we consider the two limiting cases, $P \to 0$ and $P \to 1$. For $P \to 0$, H_e is obviously given by H_{pen}, the penetration height defined in (B-29). As $P \to 1$, the new effective source height should approach L, or $H_e \to h_s + z_i'$ from (B-28), since the small fractional plume of thickness $(1-P)\Delta h$ that is left at the top of the mixed layer vanishes in the limit $P \to 1$.

Now, from simple geometric considerations, a general expression for H_e valid for any value of P ($0 \leqq P \leqq 1$) can be written as

$$H_e = h_s + [z_i' - 0.5\ (1-P)\Delta h]$$

Substituting $\Delta h = z_i'/(1.5-P)$ from (B-30) in the above, we obtain

$$H_e = h_s + [(1-0.5\ P)/(1.5-P)]z_i' \tag{B-34}$$

This equation for H_e is consistent with the definition of P, and also satisfies the limiting behavior, for P=0 and P=1, discussed above. The elevations (above the stack) of the upper and lower edges of the plume

material whose centerline is given by (B-34) are z_i' and $z_i'/(3-2P)$, respectively. The solid lines in Figure (B-1) show the variations of normalized elevations of the centerline and edges of this plume as functions of P.

Equation (B-34) for H_e differs from that given by Weil and Brower (1982), who interpolated linearly between the limiting values of H_e at P=0 and P=1, as follows:

$$H_e = h_s + [(2+P)/3]z_i' \qquad \text{(B-35)}$$

The elevations of the upper and lower edges of the plume whose centerline is given by (B-35) are z_i' and $(1+2P)z_i'/3$, respectively. Figure (B-1) shows the centerline and lower edge of this plume in broken lines. It is clear that, though both (B-34) and (B-35) give the same values for H_e at P=0 and P=1, the linear model consistently overpredicts the effective source height of the fractional plume left in the mixed layer for $0 < P < 1$. At P=0.5, for example, (B-35) overpredicts H_e by about 11 percent, and the elevation of the lower edge is overestimated by about 33 percent.

For $0 \leqq P < 1$, the distance downwind from the stack to the location where the new effective source height H_e occurs can be obtained by equating the plume rise from (B-34) to the distance-dependent plume rise given by (B-2) and solving for x:

$$x_{max} = [(1-0.5P)z_i' \, U \, / \, 1.6(1.5-P)]^{3/2} \, F_b^{-1/2} \qquad \text{(B-36)}$$

For $x < x_{max}$, the plume rise is predicted from (B-2); for $x \geqq x_{max}$, H_e is given by (B-34).

The various formulas for computing the effective source height and effective source strength can be summarized as follows:

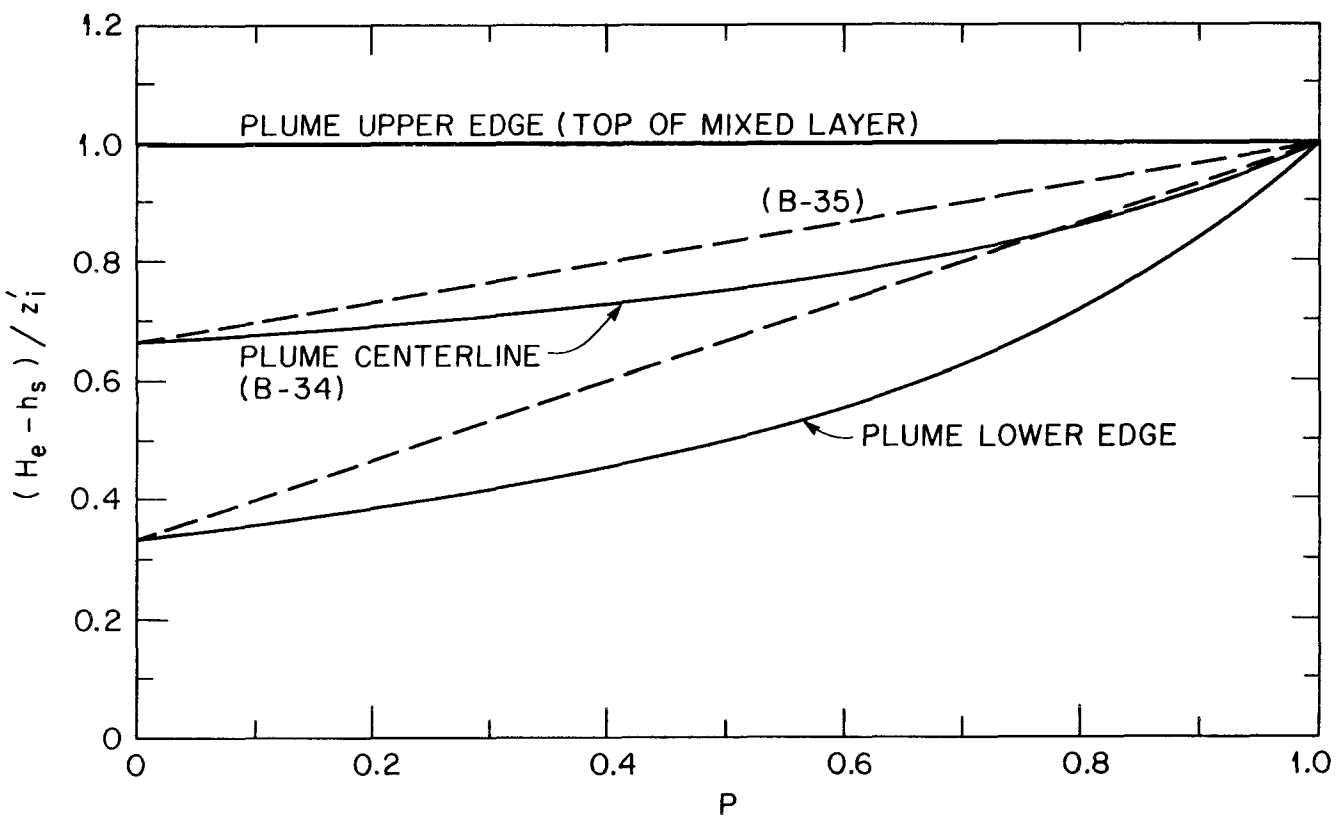

Figure (B-1). Variation of the elevation (above the stack) of the fractional plume left within the mixed layer as a function of the plume penetration fraction. Solid lines show the plume centerline given by Eq. (B-34), and upper and lower edges of the plume for the partial penetration model used in PEM-2. Broken lines show the corresponding plume centerline given by Eq. (B-35), and the lower edge from the linear interpolation model of Weil and Brower (1982). The plume upper edge is the same in both models.

(a) For $H < H_{pen}$, the plume does not penetrate the elevated stable layer, and penetration need not be considered.

$$H_e = H$$
$$Q_{ek} = Q_k \ , \quad k = 1,2 \tag{B-37}$$

(b) For $H \geqq H_{pen}$, the plume penetration fraction P should be computed from (B-30) and (B-31). Then, depending on the value of P, one of the following applies:

(i) For P=1, the entire plume penetrates the elevated stable layer, and the source is ignored since it does not contribute to the GLC.

$$H_e \geqq L$$
$$Q_{ek} = 0 \tag{B-38}$$

(ii) For P=0, the entire plume remains within the mixed layer and contributes to the GLC.

$$H_e = H_{pen}$$
$$Q_{ek} = Q_k \tag{B-39}$$

(iii) For $0 < P < 1$, the plume partially penetrates the elevated stable layer; only the fraction (1-P) of the plume material left in the mixed layer contributes to the GLC.

$$H_e = h_s + [(1-0.5P)/(1.5-P)]z_i'$$
$$Q_{ek} = (1-P)\ Q_k \tag{B-40}$$

For cases (ii) and (iii), the downwind distance x_{max} to the effective source height is estimated from (B-36).

REFERENCES

Briggs, G. A., 1969: Plume Rise. AEC Critical Review Series. Available as TID-25075 from NTIS, Springfield, VA, 81 pp.

_____, 1971: Some recent analyses of plume rise observations. Proc. of 2nd Int. Clean Air Congress, H. M. Englund and W. T. Beery, eds. Academic Press, New York, 1029-1032.

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Turner, D. B., 1985: Proposed pragmatic methods for estimating plume rise and plume penetration through atmospheric layers. Atmos. Environ. 19, 1215-1218.

Weil, J. C., and R. B. Brower, 1982: The Maryland PPSP Dispersion Model for Tall Stacks. Report PPSP-MP-36, Environ. Center, Martin Marietta Corp., Baltimore, MD.

APPENDIX C

SURFACE DEPOSITION FLUXES, AND DEPOSITION AND SETTLING VELOCITIES

C.1 SURFACE DEPOSITION FLUXES

The surface deposition fluxes of the primary and the secondary pollutants at ground level receptors are calculated directly as

$$D_1(\hat{x},\hat{y}) = V_{d1} \cdot C_1(\hat{x},\hat{y},0) \tag{C-1}$$

$$D_2(\hat{x},\hat{y}) = V_{d2} \cdot C_2(\hat{x},\hat{y},0) \tag{C-2}$$

D_i gives the amount of pollutant i deposited per unit time per unit surface area, and is usually calculated in the short term as $\mu g/m^2$-hr or kg/km^2-hr, while seasonal estimates are expressed as kg/km^2-month. The estimation of the monthly or yearly surface deposition fluxes at a given downwind distance x from the source in a given wind-directional sector requires the knowledge of the fraction of the time that a mean wind of a given magnitude blows in that direction in a month or a year, respectively. To obtain D_i in kg/km^2-hr when V_{di} is given in cm/s and C_i in $\mu g/m^3$, the right-hand side of the equations should be multiplied by 0.036. To obtain D_i in $\mu g/m^2$-hr when V_{di} is given in cm/s and C_i in $\mu g/m^3$, the corresponding multiplication factor is 36. For D_i calculations, the ground-level receptor is generally defined as any receptor which is not higher than 1 meter above the local ground-level elevation.

PEM-2 calculates the surface deposition fluxes of one or two pollutants. These values are printed in a map or list form, as specified by the user, in the same way the program prints the concentrations. The flux units are generally $\mu g/m^2$-hr; however, if these values are too large to be clearly printed in a map format, the program automatically converts them into kg/km^2-hr before printing.

C.2 DEPOSITION AND SETTLING VELOCITIES

The values of the settling and deposition velocities primarily depend on the particle diameter d. (i) In the trivial case of $W = V_d = 0$, settling and deposition effects are negligible. (ii) For very small particles ($d < 0.1$ μm), gravitational settling can be neglected, and dry deposition occurs primarily due to nongravitational effects. In this case, $W = 0$ but $V_d > 0$. (iii) For small to medium-sized particles ($d = 0.1 \sim 50$μm), $0 < W < V_d$; deposition is enhanced here beyond that due to gravitational settling, primarily because of increased turbulent transfer resulting from surface roughness. (iv) For larger particles ($d > 50$ μm), it is generally assumed that $V_d = W > 0$, since gravitational settling is the dominant deposition mechanism. (v) When $W > V_d > 0$, turbulent re-entrainment of the deposited particles from the surface back into the atmosphere is implied, as in a dust storm, for example. Model parameters such as those given above for cases (i) to (iv) are widely used in the atmospheric dispersion and deposition of particulate material. The deposition of gases is a special case of the particulate problem with $W = 0$; this is similar to case (ii). Thus, one has to carefully select the values of W and V_d for use in the models. A more complete discussion of these model parameters is given by Rao (1982).

REFERENCE

Rao, K. S., 1982: Plume Concentration Algorithms with Deposition, Sedimentation, and Chemical Transformation. EPA-600/3-84-042, U.S. Environmental Protection Agency, Research Triangle Park, NC, 87 pp. [NTIS PB 84-138 742].

D01AJF – NAG FORTRAN Library Routine Document

NOTE: before using this routine, please read the appropriate implementation document to check the interpretation of bold *italicised* terms and other implementation–dependent details. The routine name may be precision–dependent.

1. Purpose

D01AJF is a general-purpose integrator which calculates an approximation to the integral of a function F(x) over a finite interval (A,B):

$$I = \int_A^B F(x)\,dx.$$

2. Specification

```
      SUBROUTINE D01AJF (F, A, B, EPSABS, EPSREL, RESULT, ABSERR,
     1   W, LW, IW, LIW, IFAIL)
C     INTEGER LW, IW(LIW), LIW, IFAIL
C     real F, A, B, EPSABS, EPSREL, RESULT, ABSERR, W(LW)
C     EXTERNAL F
```

3. Description

D01AJF is based upon the QUADPACK [3] routine DQAGS. It is an adaptive routine, using the Gauss 10–point and Kronrod 21–point rules. The algorithm, described in [1], incorporates a global acceptance criterion (as defined by Malcolm and Simpson [2]) together with the ϵ–algorithm [4] to perform extrapolation. The local error estimation is described in [3].

The routine is suitable as a general purpose integrator, and can be used when the integrand has singularities, especially when these are of algebraic or logarithmic type.

4. References

[1] DE DONCKER, E.
An Adaptive Extrapolation Algorithm for Automatic Integration.
Signum Newsletter 13, No. 2, pp. 12–18, 1978.

[2] MALCOLM, M.A. and SIMPSON, R.B.
Local versus Global Strategies for Adaptive Quadrature.
A.C.M. Trans. Math. Software 1, pp. 129–146, 1976.

[3] PIESSENS, R., DE DONCKER, E., ÜBERHUBER, C. and KAHANER, D.
'QUADPACK', A Quadrature Subroutine Package.
To be published, 1980.

[4] WYNN, P.
On a Device for Computing the $e_m(S_n)$ Transformation.
M.T.A.C, 10, pp. 91–96, 1956.

5. Parameters

F – *real* FUNCTION, supplied by the user.

F must return the value of the integrand at a given point.
Its specification is:

```
real FUNCTION F(X)
real X
```

X – *real.*

On entry, X specifies the point at which the integrand value is required by D01AJF. X must not be reset by F.

F must be declared as EXTERNAL in the (sub)program from which D01AJF is called.

A – *real.*

On entry, A must specify the lower limit of integration.

Unchanged on exit.

B – *real.*

On entry, B must specify the upper limit of integration.

Unchanged on exit.

EPSABS – *real.*

On entry, EPSABS must specify the absolute accuracy required. If EPSABS is negative, the absolute value is used. See Section 10.

Unchanged on exit.

EPSREL – *real.*

On entry, EPSREL must specify the relative accuracy required. If EPSREL is negative, the absolute value is used. See Section 10.

Unchanged on exit.

RESULT – *real.*

On exit, RESULT contains the approximation to the integral I.

ABSERR – *real.*

On exit, ABSERR contains an estimate of the modulus of the absolute error, which should be an upper bound for $|I-\text{RESULT}|$.

W – *real* array of DIMENSION (LW).

Used as workspace.

LW – INTEGER.

On entry, LW must specify the dimension of W as declared in the calling (sub)program. LW/4 is an upper bound for the number of subintervals into which the interval of integration is divided. A value in the range 800 to 2000 is adequate for most problems. The more difficult the integrand, the larger LW should be. Trivially LW $\geq$ 4. See IW below.

LW is unchanged on exit.

IW – INTEGER array of DIMENSION (LIW).

Used as workspace.

On exit, IW(1) contains the amount of *real* workspace actually used (the smallest possible value of LW).

LIW – INTEGER.

On entry, LIW must specify the dimension of IW, as declared in the calling (sub)program. LIW $\geq$ LW/8 + 2.

Unchanged on exit.

IFAIL – INTEGER.

Before entry, IFAIL must be assigned a value. For users not familiar with this parameter (described in Chapter P01) the recommended value is 0.

Unless the routine detects an error (see next section), IFAIL contains 0 on exit.

6. Error Indicators and Warnings

Errors detected by the routine.–

IFAIL = 1

The maximum number of subdivisions allowed with the given workspace has been reached without the accuracy requirements being achieved. Look at the integrand in order to determine the integration difficulties. If the position of a local difficulty within the interval can be determined (e.g. a singularity of the integrand or its derivative, a peak, a discontinuity...) one will probably gain from splitting up the interval at this point and calling the integrator on the subranges. If necessary, another integrator which is designed for handling the type of difficulty involved, must be used. Alternatively consider relaxing the accuracy requirements specified by EPSABS and EPSREL, or increasing the amount of workspace.

IFAIL = 2

Roundoff error prevents the requested tolerance from being achieved. The error may be under-estimated. Consider requesting less accuracy.

IFAIL = 3

Extremely bad local integrand behaviour causes a very strong subdivision around one (or more) points of the interval. The same advice applies as in the case of IFAIL = 1.

IFAIL = 4

The requested tolerance cannot be achieved, because the extrapolation does not increase the accuracy satisfactorily; the returned result is the best which can be obtained. The same advice applies as in the case of IFAIL = 1.

IFAIL = 5

The integral is probably divergent, or slowly convergent. It must be noted that divergence can also occur with any non-zero value of IFAIL.

IFAIL = 6

On entry, LW $<$ 4, or LIW $<$ LW/8 + 2.

7. Auxiliary Routines

This routine calls NAG Library routines D01AJV, D01AJX, D01AJY, D01AJZ, P01AAF, X02AAF, X02ABF and X02ACF.

8. Timing

This depends on the integrand and the accuracy required.

9. Storage

The storage required by internally declared arrays is 107 *real* elements.

10. Accuracy

The routine cannot guarantee, but in practice usually achieves, the following accuracy:

$|I - \text{RESULT}| \leq tol$

where

$tol = \max(|\text{EPSABS}|, |\text{EPSREL}| \times |I|)$

and EPSABS and EPSREL are user-specified absolute and relative error tolerance. Moreover it returns the quantity ABSERR which, in normal circumstances, satisfies $|I - \text{RESULT}| \leq \text{ABSERR} \leq tol$.

11. Further Comments

Labelled COMMON block AD01AJ is used by this routine and must therefore be avoided by the user.

12. Keywords

Quadrature, Extrapolation, Globally Adaptive, Singularities.

---

13. Example

To compute $$\int_0^{2\pi} \frac{x.\sin(30x)}{\sqrt{(1-(\frac{x}{2\pi})^2)}}\,dx$$

WARNING: This single precision example program may require amendment for certain implementations. The results produced may not be the same. If in doubt, please seek further advice (see Essential Introduction to the Library Manual).

13.1. Program Text

```
C     D01AJF EXAMPLE PROGRAM TEXT
C     MARK 8 RELEASE. NAG COPYRIGHT 1979.
C     .. SCALARS IN COMMON ..
      REAL PI
      INTEGER KOUNT
C     ..
C     .. LOCAL SCALARS ..
      REAL A, ABSERR, B, EPSABS, EPSREL, EX, EXACT, RESULT
      INTEGER IFAIL, NOUT
C     .. LOCAL ARRAYS ..
      REAL W(800)
      INTEGER IW(102)
C     .. FUNCTION REFERENCES ..
      REAL X01AAF
C     .. SUBROUTINE REFERENCES ..
C     D01AJF
C     ..
      EXTERNAL FST
      COMMON /TELNUM/ PI, KOUNT
      DATA EXACT /-0.25432596158935 30E+01/
      DATA NOUT /6/
      WRITE (NOUT,99999)
      PI = X01AAF(PI)
      EPSABS = 0.E0
      EPSREL = 1.E-04
      A = 0.E0
      B = 2.E0*PI
      KOUNT = 0
      IFAIL = 1
      CALL D01AJF(FST, A, B, EPSABS, EPSREL, RESULT, ABSERR, W,
     * 800, IW, 102, IFAIL)
      WRITE (NOUT,99998) A, B, EPSABS, EPSREL
      WRITE (NOUT,99997) RESULT, ABSERR, KOUNT, IW(1), IFAIL
      EX = ABS(EXACT-RESULT)
      WRITE (NOUT,99996) EX
      STOP
99999 FORMAT (40(1X/), 31H D01AJF EXAMPLE PROGRAM RESULTS/1X)
99998 FORMAT (1H , 2X, 1HA, 6X, 31H- LOWER LIMIT OF INTEGRATION
```

```
     * F10.4/1H , 2X, 1HB, 6X, 31H- UPPER LIMIT OF INTEGRATION - ,
     * F10.4/1H , 2X, 39HEPSABS - ABSOLUTE ACCURACY REQUESTED - ,
     * E9.2/1H , 2X, 39HEPSREL - RELATIVE ACCURACY REQUESTED - ,
     * E9.2/)
99997 FORMAT (1H , 2X, 41HRESULT - APPROXIMATION TO THE INTEGRAL - ,
     * E14.5/1H , 2X, 42HABSERR - ESTIMATE OF THE ABSOLUTE ERROR - ,
     * E10.3/1H , 2X, 42HKOUNT  - NUMBER OF FUNCTION EVALUATIONS - ,
     * I4/1H , 2X, 43HIW(1)  - ELEMENTS OF REAL WORKSPACE USED - ,
     * I4/1H , 2X, 22HIFAIL  - ERROR FLAG - , I4/)
99996 FORMAT (1H , 7X, 27H  - EXACT ABSOLUTE ERROR - , E10.3)
      END
      REAL FUNCTION FST(X)
C     - SCALAR ARGUMENTS -
      REAL X
C     -
C     - SCALARS IN COMMON -
      REAL PI
      INTEGER KOUNT
C     -
C     - FUNCTION REFERENCES -
      REAL SIN, SQRT
C     -
      COMMON /TELNUM/ PI, KOUNT
      KOUNT = KOUNT + 1
      FST = X*SIN(30.E0*X)/SQRT(1.E0-X**2/(4.E0*PI**2))
      RETURN
      END
C     D01AJF EXAMPLE PROGRAM TEXT
C     MARK 8 RELEASE. NAG COPYRIGHT 1979.
```

13.2. Program Data

None.

13.3. Program Results

```
D01AJF EXAMPLE PROGRAM RESULTS

 A      - LOWER LIMIT OF INTEGRATION -      0.0000
 B      - UPPER LIMIT OF INTEGRATION -      6.2832
 EPSABS - ABSOLUTE ACCURACY REQUESTED -  0.00E 00
 EPSREL - RELATIVE ACCURACY REQUESTED -  0.10E-03

 RESULT - APPROXIMATION TO THE INTEGRAL -   -0.25433E 01
 ABSERR - ESTIMATE OF THE ABSOLUTE ERROR -  0.125E-04
 KOUNT  - NUMBER OF FUNCTION EVALUATIONS -  777
 IW(1)  - ELEMENTS OF REAL WORKSPACE USED -  76
 IFAIL  - ERROR FLAG -    0

        - EXACT ABSOLUTE ERROR -  0.893E-05
```

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APPENDIX E

INPUT AND OUTPUT LISTINGS OF EXAMPLE PROBLEMS

The input data and output listings for the PEM-2 example problems described in Section 4.5 are shown in the tables of this Appendix as follows:

Table Number		Page
E-1	Input data for Example Problem 1	93
E-2	Output listing for Example Problem 1	94
E-3	Input data for Example Problem 2(a)	106
E-4	Output listing for Example Problem 2(a)	107
E-5	Input data for Example Problem 2(b)	120
E-6	Output listing for Example Problem 2(b)	121
E-7	Input data for Example Problem 3	134
E-8	Output listing for Example Problem 3	135

TABLE E-1

INPUT DATA FOR EXAMPLE PROBLEM 1

CARD IMAGES

```
CONTROL CARDS
1  TITLE    PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX
2  OPTIONS    3   0   0   0   3   0   2   0   0   1   1   1   1   1   0   1   1   0
3  GRID          0.        0.       25       25       1.       0.       0.
4  POLLUTANTS  2   1        1.       0.      0.1       0.      1.0      1.5
5  SCALING       10.       1.       1.       0.       0.       0.       0.
6  LABELS  SO2                                   SULFATE
SCENARIO CARDS

              4   4   11       4.      225.       5.     550.      0.
              5   4   11       3.      225.       5.     500.      0.
              6   4   11       2.      225.       5.     500.      0.
AREA SOURCE CARDS
                1.5      10.5    1000.      10.      1.
                3.5       3.5    4000.      90.      9.
                9.5        .5    2000.      20.      2.
                9.5        .5    1000.       5.      .5
           (A BLANK CARD TO SIGNAL END OF AREA SOURCE INVENTORY)
```

TABLE E-2

OUTPUT LISTING FOR EXAMPLE PROBLEM 1

PEM-2 (VERSION 84130)

POLLUTION EPISODIC MODEL

INCLUDING

DEPOSITION, SEDIMENTATION, AND CHEMICAL TRANSFORMATION

OF POLLUTANTS

POLLUTION EPISODIC MODEL (PEM-2)

INPUT CONTROL PARAMETERS: PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX

AVERAGING TIME OPTION: NTOPT=3

A SCENARIO IS A SET OF METEOROLOGICAL DATA FOR ONE HOUR

1 1 HOUR: CONCENTRATIONS ARE CALCULATED FOR EACH SCENARIO
2 24 HOURS: CONCENTRATIONS CALCULATED FOR 24 SCENARIOS ARE AVERAGED
3 VARIABLE: CONCENTRATIONS CALCULATED FOR A GIVEN NUMBER (2 TO 23) OF SCENARIOS ARE AVERAGED

WIND DIRECTION OPTION: NWDOPT=0

0 DIRECTION IN DEGREES TO BE SPECIFIED FOR EACH SCENARIO
1 SECTOR NUMBER TO BE SPECIFIED FOR EACH SCENARIO
2-7 DIRECTION IN DEGREES TO BE SPECIFIED FOR THE FIRST OF FOUR SUB-SCENARIOS.
FOR EACH SUCCEEDING SUB-SCENARIO, WIND DIRECTION IS AUTOMATICALLY INCREASED
BY 90,45,30,15,10,OR 5 DEGREES, DEPENDING ON THE OPTION NUMBER SELECTED.

WIND SPEED OPTION: NWSOPT=0

0 SPEED IN M/S TO BE SPECIFIED FOR EACH SCENARIO
1 WIND SPEED CLASS NUMBER TO BE SPECIFIED FOR EACH SCENARIO

NUMBER OF SCENARIOS: NSCEN= 3

RECEPTOR GRID: COLUMNS: LX= 25 ROWS: LY= 25
SPACING: GRID= 1.000 KM
SOUTHWEST CORNER XRSWC= 0.0 KM W
YRSWC= 0.0 KM S

POLLUTION EPISODIC MODEL (PEM-2)

INPUT CONTROL PARAMETERS: PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX

NUMBER OF POLLUTANTS: NPOL=2

	POLLUTANT-1: SO2	POLLUTANT-2: SULFATE
AREA SOURCE SCALING FACTOR:	ASCALE= 1.000	ASCALE= 1.000
CALIBRATION COEFFICIENTS:	A= 0.0 B= 0.0	A= 0.0 B= 0.0
CALIBRATION IDENTIFICATION:		
DEPOSITION VELOCITY (CM/S):	VD1= 1.000	VD2= 0.100
SETTLING VELOCITY (CM/S):	W1= 0.0	W2= 0.0

CHEMICAL TRANSFORMATION OPTION: ICT=1

NPOL=2
ICT=0 CHEMICAL TRANSFORMATION LOSS OF POLLUTANTS IS IGNORED
ICT=1 FIRST-ORDER CHEMICAL TRANSFORMATION OF POLLUTANT-1 TO POLLUTANT-2 IS CONSIDERED

CHEMICAL TRANSFORMATION OR DECAY RATE: XKT= 1.000 PERCENT/HR

RATIO OF MOLECULAR WEIGHTS OF POLLUTANT-2 (PRODUCT) TO POLLUTANT-1 (REACTANT): GAMMA= 1.500

OUTPUT OPTIONS SELECTED:

NARRAY=2 MAPS OF CONCENTRATION AND SURFACE DEPOSITION FLUX AT EACH RECEPTOR IN THE GRID, UNCALIBRATED ONLY
NMAX=1 LIST OF RECEPTORS WITH HIGHEST CONCENTRATION AND SURFACE DEPOSITION FLUX FOR EACH SCENARIO - PRINTED AT END OF RUN

POLLUTION EPISODIC MODEL (PEM-2)

INPUT SCENARIO PARAMETERS: PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX

WIND DIRECTIONS

SECTOR NUMBER	DIRECTION (DEG)		SECTOR NUMBER	DIRECTION (DEG)	
1	N	0.0	9	S	180.0
2	NNE	22.5	10	SSW	202.5
3	NE	45.0	11	SW	225.0
4	ENE	67.5	12	WSW	247.5
5	E	90.0	13	W	270.0
6	ESE	112.5	14	WNW	292.5
7	SE	135.0	15	NW	315.0
8	SSE	157.5	16	NNW	337.5

WIND SPEED CLASSES

CLASS INDEX	SPEED (M/S)	CLASS INTERVAL(KT)
1	1.50	0-3
2	2.46	4-6
3	4.47	7-10
4	6.93	11-16
5	9.61	17-21
6	12.52	OVER 21

STABILITY CLASSES

CLASS INDEX	CLASS
1	A
2	B
3	C
4	D
5	E
6	F

SCENARIO NUMBER	STABILITY CLASS	WIND SPEED CLASS	WIND SPEED (M/S)	WIND SECTOR	WIND DIRECTION (DEG)	AMBIENT TEMPERATURE (DEG C)	TEMP GRADIENT ABOVE MIXING HEIGHT (DEG/M)	MIXING HEIGHT (M)
1	D		4.000		225.00	5.00	0.010	550.0
2	E		3.000		225.00	5.00	0.010	500.0
3	F		2.000		225.00	5.00	0.010	500.0

POLLUTION EPISODIC MODEL (PEM-2)

INPUT AREA SOURCE PARAMETERS: PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX

AREA SOURCE NUMBER	COORDINATES X(KM)	COORDINATES Y(KM)	LENGTH OF SIDE (M)	POLLUTANT-1 EMISSION RATE INPUT (G/S)	POLLUTANT-1 EMISSION RATE SCALED	POLLUTANT-2 EMISSION RATE INPUT (G/S)	POLLUTANT-2 EMISSION RATE SCALED
1	1.50	10.50	1000.00	10.000	10.000	1.000	1.000
2	3.50	3.50	4000.00	90.000	90.000	9.000	9.000
3	9.50	0.50	2000.00	20.000	20.000	2.000	2.000
4	9.50	0.50	1000.00	5.000	5.000	0.500	0.500
SUMS OF THE AREA SOURCE EMISSION RATES				125.000	125.000	12.500	12.500

EFFECTIVE HEIGHT OF THE AREA SOURCE EMISSIONS = 10.00 M

POLLUTION EPISODIC MODEL (PEM-2)

INPUT POINT SOURCE PARAMETERS: PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX

POINT SOURCE NUMBER	LABEL	COORDINATES X(KM)	Y(KM)	EMISSION RATE POLLUTANT-1 (G/S)	EMISSION RATE POLLUTANT-2 (G/S)	HEIGHT (M)	DIAMETER (M)	EXIT VEL (M/S)	EXIT T (DEG)

SUMS OF THE POINT SOURCE EMISSION RATES 0.0 G/S 0.0 G/S

PEM-2 OUTPUT: SECTION 1 OF 1 PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX
3 SCENARIOS, AVERAGING TIME= 3 HRS. POLLUTANT-1: SO2
UNCALIBRATED CONCENTRATION - MICROGRAMS PER CUBIC METER

	0.0		2.00		4.00		6.00		8.00		10.00		12.00		14.00		16.00		18.00		20.00		22.00		24.00
24.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.00	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.00	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.00	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.00	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.00	0	0	0	0	0	0	16	0	0	0	0	0	6	6	6	6	0	0	0	0	0	0	0	0	0
14.00	0	0	0	0	0	20	0	0	0	0	0	6	12	12	12	6	0	0	0	0	0	0	0	0	0
13.00	0	0	0	0	27	0	0	0	0	0	7	13	19	19	12	6	0	0	0	0	0	0	0	0	0
12.00	0	0	0	48	0	0	0	0	0	8	15	21	26	19	12	6	0	0	0	0	0	0	0	0	0
11.00	0	0	65	0	0	0	0	0	9	17	24	30	21	13	6	0	0	0	0	0	0	0	0	0	0
10.00	0	0	0	0	0	0	0	11	21	29	35	24	15	7	0	0	0	0	5	5	0	0	0	0	0
9.00	0	0	0	0	0	0	15	27	36	44	29	17	8	0	0	0	0	5	15	5	0	0	0	0	0
8.00	0	0	0	0	0	27	42	54	63	36	21	9	0	0	0	0	6	17	5	0	0	0	0	0	0
7.00	0	0	0	0	36	63	79	90	54	27	11	0	0	0	0	7	19	6	0	0	0	0	0	0	0
6.00	0	0	0	0	36	63	79	79	42	15	0	0	0	0	8	22	7	0	0	0	0	0	0	0	0
5.00	0	0	0	0	36	63	63	63	27	0	0	0	0	10	27	8	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	36	36	36	36	0	0	0	0	14	34	10	0	0	0	0	0	0	0	0	0	0
3.00	0	0	0	0	0	0	0	0	0	0	0	24	51	14	0	0	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	32	80	24	0	0	0	0	0	0	0	0	0	0	0	0
1.00	0	0	0	0	0	0	0	0	0	0	65	32	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		2.00		4.00		6.00		8.00		10.0		12.00		14.00		16.00		18.00		20.00		22.00		24.00

PEM-2 OUTPUT: SECTION 1 OF 1 PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX
3 SCENARIOS, AVERAGING TIME= 3 HRS. POLLUTANT-1: SO2
UNCALIBRATED SURFACE DEPOSITION FLUX - KILOGRAMS PER SQUARE KILOMETER PER HOUR

	0.0		2.00		4.00		6.00		8.00		10.00		12.00		14.00		16.00		18.00		20.00		22.00		24.00
24.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.00	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.00	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.00	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.00	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
12.00	0	0	0	2	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
11.00	0	0	2	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
10.00	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
9.00	0	0	0	0	0	0	1	1	1	2	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
8.00	0	0	0	0	0	1	2	2	2	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
7.00	0	0	0	0	1	2	3	3	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
6.00	0	0	0	0	1	2	3	3	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
5.00	0	0	0	0	1	2	2	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
3.00	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0
1.00	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		2.00		4.00		6.00		8.00		10.00		12.00		14.00		16.00		18.00		20.00		22.00		24.00

PEM-2 OUTPUT: SECTION 1 OF 1 PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX
3 SCENARIOS, AVERAGING TIME= 3 HRS. POLLUTANT-2: SULFATE
UNCALIBRATED CONCENTRATION - MICROGRAMS PER CUBIC METER

	0.0		2.00		4.00		6.00		8.00		10.00		12.00		14.00		16.00		18.00		20.00		22.00		24.00
24.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.00	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.00	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.00	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.00	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.00	0	0	0	0	0	0	2	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
14.00	0	0	0	0	0	3	0	0	0	0	0	1	2	2	2	1	0	0	0	0	0	0	0	0	0
13.00	0	0	0	0	4	0	0	0	0	0	1	2	3	3	2	1	0	0	0	0	0	0	0	0	0
12.00	0	0	0	6	0	0	0	0	0	1	2	3	4	3	2	1	0	0	0	0	0	0	0	0	0
11.00	0	0	7	0	0	0	0	0	1	3	4	5	3	2	1	0	0	0	0	0	0	0	0	0	0
10.00	0	0	0	0	0	0	0	2	3	4	5	4	2	1	0	0	0	0	1	1	0	0	0	0	0
9.00	0	0	0	0	0	0	2	4	5	6	4	3	1	0	0	0	0	1	3	1	0	0	0	0	0
8.00	0	0	0	0	0	3	5	7	8	5	3	1	0	0	0	0	1	3	1	0	0	0	0	0	0
7.00	0	0	0	0	4	7	9	11	7	4	2	0	0	0	0	1	3	1	0	0	0	0	0	0	0
6.00	0	0	0	0	4	7	9	9	5	2	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0
5.00	0	0	0	0	4	7	7	7	3	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	4	4	4	4	0	0	0	0	2	5	1	0	0	0	0	0	0	0	0	0	0
3.00	0	0	0	0	0	0	0	0	0	0	0	3	6	2	0	0	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	4	9	3	0	0	0	0	0	0	0	0	0	0	0	0
1.00	0	0	0	0	0	0	0	0	0	0	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		2.00		4.00		6.00		8.00		10.00		12.00		14.00		16.00		18.00		20.00		22.00		24.00

PEM-2 OUTPUT: SECTION 1 OF 1 PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX
3 SCENARIOS, AVERAGING TIME= 3 HRS. POLLUTANT-2: SULFATE
UNCALIBRATED SURFACE DEPOSITION FLUX - MICROGRAMS PER SQUARE METER PER HOUR

	0.0		2.00		4.00		6.00		8.00		10.00		12.00		14.00		16.00		18.00		20.00		22.00		24.00
24.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.00	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.00	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.00	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.00	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.00	0	0	0	0	0	0	9	0	0	0	0	0	4	4	4	4	0	0	0	0	0	0	0	0	0
14.00	0	0	0	0	0	10	0	0	0	0	0	4	7	7	7	4	0	0	0	0	0	0	0	0	0
13.00	0	0	0	0	13	0	0	0	0	0	4	8	11	11	7	4	0	0	0	0	0	0	0	0	0
12.00	0	0	0	21	0	0	0	0	0	4	8	12	16	11	7	4	0	0	0	0	0	0	0	0	0
11.00	0	0	26	0	0	0	0	0	5	9	13	17	12	8	4	0	0	0	0	0	0	0	0	0	0
10.00	0	0	0	0	0	0	0	6	11	15	19	13	8	4	0	0	0	0	3	3	0	0	0	0	0
9.00	0	0	0	0	0	0	7	13	18	22	15	9	4	0	0	0	0	3	10	3	0	0	0	0	0
8.00	0	0	0	0	0	12	19	25	30	18	11	5	0	0	0	0	4	10	3	0	0	0	0	0	0
7.00	0	0	0	0	14	26	33	39	25	13	6	0	0	0	0	4	11	4	0	0	0	0	0	0	0
6.00	0	0	0	0	14	26	33	33	19	7	0	0	0	0	4	12	4	0	0	0	0	0	0	0	0
5.00	0	0	0	0	14	26	26	26	12	0	0	0	0	5	14	4	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	14	14	14	14	0	0	0	0	6	17	5	0	0	0	0	0	0	0	0	0	0
3.00	0	0	0	0	0	0	0	0	0	0	0	10	23	6	0	0	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	13	33	10	0	0	0	0	0	0	0	0	0	0	0	0
1.00	0	0	0	0	0	0	0	0	0	0	26	13	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		2.00		4.00		6.00		8.00		10.00		12.00		14.00		16.00		18.00		20.00		22.00		24.00

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX

HIGHEST PREDICTED CONCENTRATION OF EACH POLLUTANT FOR EACH SCENARIO OR AVERAGING PERIOD

UNCALIBRATED CONCENTRATION IN MICROGRAMS PER CUBIC METER - CALIBRATION, POLLUTANT-1:
CALIBRATION, POLLUTANT-2:

		POLLUTANT-1: SO2				POLLUTANT-2: SULFATE			
SCENARIO NUMBER	WIND DIRECTION SUB-SCENARIO	COORDINATES X(KM)	COORDINATES Y(KM)	CONCENTRATION UNCALIBRATED	CONCENTRATION CALIBRATED	COORDINATES X(KM)	COORDINATES Y(KM)	CONCENTRATION UNCALIBRATED	CONCENTRATION CALIBRATED
1		7.00	7.00	90.0691	0.0	7.00	7.00	10.8144	0.0

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 1: MULTIPLE AREA SOURCES, 2 SPECIES, 3-HR AVG CONC & DEP FLUX

HIGHEST PREDICTED SURFACE DEPOSITION FLUX OF EACH POLLUTANT FOR EACH SCENARIO OR AVERAGING PERIOD

UNCALIBRATED VALUES IN MICROGRAMS PER SQUARE METTER PER HOUR - CALIBRATION, POLLUTANT-1:
CALIBRATION, POLLUTANT-2:

		POLLUTANT-1: SO2				POLLUTANT-2: SULFATE			
SCENARIO NUMBER	WIND DIRECTION SUB-SCENARIO	COORDINATES X(KM)	Y(KM)	SURFACE DEPOSITION FLUX UNCALIBRATED	CALIBRATED	COORDINATES X(KM)	Y(KM)	SURFACE DEPOSITION FLUX UNCALIBRATED	CALIBRATED
1		7.00	7.00	3242.4875	0.0	7.00	7.00	38.9317	0.0

TABLE E-3

INPUT DATA FOR EXAMPLE PROBLEM 2A

CARD IMAGES

```
CONTROL CARDS
1  TITLE     PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES
2  OPTIONS     1   1   1   0   1   0   2   0   0   1   0   1   1   1   1   1   1   0
3  GRID            0.        0.        25        25        2.        0.        0.
4  POLLUTANTS  2   1.        2.        0.       0.5       0.2       10.       1.5
5  SCALING         0.        1.        1.        0.        0.        0.        0.
6  LABLES  SO2                                     SULFATE
SCENARIO CARDS
               4   2.   9       0.        0.         25.        550.    0.001
            (A BLANK CARD TO SIGNAL END OF AREA SOURCE INVENTORY)
POINT SOURCE CARDS
           30.      2.    1000.      50.       200.         5.      10.    450. STACK 1
           10.      2.     500.      25.       200.         4.       8.    400. STACK 2
      (A BLANK CARD TO SIGNAL END OF POINT SOURCE INVENTORY)
```

TABLE E-4

OUTPUT LISTING FOR EXAMPLE PROBLEM 2A

PEM-2 (VERSION 84130)

POLLUTION EPISODIC MODEL

INCLUDING

DEPOSITION, SEDIMENTATION, AND CHEMICAL TRANSFORMATION

OF POLLUTANTS

POLLUTION EPISODIC MODEL (PEM-2)

INPUT CONTROL PARAMETERS: PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES

AVERAGING TIME OPTION: NTOPT=1

A SCENARIO IS A SET OF METEOROLOGICAL DATA FOR ONE HOUR

1 1 HOUR: CONCENTRATIONS ARE CALCULATED FOR EACH SCENARIO
2 24 HOURS: CONCENTRATIONS CALCULATED FOR 24 SCENARIOS ARE AVERAGED
3 VARIABLE: CONCENTRATIONS CALCULATED FOR A GIVEN NUMBER (2 TO 23) OF SCENARIOS ARE AVERAGED

WIND DIRECTION OPTION: NWDOPT=1

0 DIRECTION IN DEGREES TO BE SPECIFIED FOR EACH SCENARIO
1 SECTOR NUMBER TO BE SPECIFIED FOR EACH SCENARIO
2-7 DIRECTION IN DEGREES TO BE SPECIFIED FOR THE FIRST OF FOUR SUB-SCENARIOS.
FOR EACH SUCCEEDING SUB-SCENARIO, WIND DIRECTION IS AUTOMATICALLY INCREASED
BY 90,45,30,15,10,OR 5 DEGREES, DEPENDING ON THE OPTION NUMBER SELECTED.

WIND SPEED OPTION: NWSOPT=1

0 SPEED IN M/S TO BE SPECIFIED FOR EACH SCENARIO
1 WIND SPEED CLASS NUMBER TO BE SPECIFIED FOR EACH SCENARIO

NUMBER OF SCENARIOS: NSCEN= 1

RECEPTOR GRID: COLUMNS: LX= 25 ROWS: LY= 25
SPACING: GRID= 2.000 KM
SOUTHWEST CORNER XRSWC= 0.0 KM W
YRSWC= 0.0 KM S

POLLUTION EPISODIC MODEL (PEM-2)

INPUT CONTROL PARAMETERS: PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES

NUMBER OF POLLUTANTS: NPOL=2

	POLLUTANT-1: SO2	POLLUTANT-2: SULFATE
AREA SOURCE SCALING FACTOR:	ASCALE= 1.000	ASCALE= 1.000
CALIBRATION COEFFICIENTS:	A= 0.0 B= 0.0	A= 0.0 B= 0.0
CALIBRATION IDENTIFICATION:		
DEPOSITION VELOCITY (CM/S):	VD1= 2.000	VD2= 0.500
SETTLING VELOCITY (CM/S):	W1= 0.0	W2= 0.200

CHEMICAL TRANSFORMATION OPTION: ICT=1

NPOL=2
ICT=0 CHEMICAL TRANSFORMATION LOSS OF POLLUTANTS IS IGNORED
ICT=1 FIRST-ORDER CHEMICAL TRANSFORMATION OF POLLUTANT-1 TO POLLUTANT-2 IS CONSIDERED

CHEMICAL TRANSFORMATION OR DECAY RATE: XKT= 10.000 PERCENT/HR

RATIO OF MOLECULAR WEIGHTS OF POLLUTANT-2 (PRODUCT) TO POLLUTANT-1 (REACTANT): GAMMA= 1.500

OUTPUT OPTIONS SELECTED:

NARRAY=2 MAPS OF CONCENTRATION AND SURFACE DEPOSITION FLUX AT EACH RECEPTOR IN THE GRID, UNCALIBRATED ONLY
NMAX=1 LIST OF RECEPTORS WITH HIGHEST CONCENTRATION AND SURFACE DEPOSITION FLUX FOR EACH SCENARIO - PRINTED AT END OF RUN

POLLUTION EPISODIC MODEL (PEM-2)

INPUT SCENARIO PARAMETERS: PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES

WIND DIRECTIONS

SECTOR NUMBER	DIRECTION	(DEG)	SECTOR NUMBER	DIRECTION	(DEG)
1	N	0.0	9	S	180.0
2	NNE	22.5	10	SSW	202.5
3	NE	45.0	11	SW	225.0
4	ENE	67.5	12	WSW	247.5
5	E	90.0	13	W	270.0
6	ESE	112.5	14	WNW	292.5
7	SE	135.0	15	NW	315.0
8	SSE	157.5	16	NNW	337.5

WIND SPEED CLASSES

CLASS INDEX	SPEED (M/S)	CLASS INTERVAL(KT)
1	1.50	0-3
2	2.46	4-6
3	4.47	7-10
4	6.93	11-16
5	9.61	17-21
6	12.52	OVER 21

STABILITY CLASSES

CLASS INDEX	CLASS
1	A
2	B
3	C
4	D
5	E
6	F

SCENARIO NUMBER	STABILITY CLASS	WIND SPEED CLASS	WIND SPEED (M/S)	WIND SECTOR	WIND DIRECTION (DEG)	AMBIENT TEMPERATURE (DEG C)	TEMP GRADIENT ABOVE MIXING HEIGHT (DEG/M)	MIXING HEIGHT (M)
1	D	2		9		25.00	0.001	550.0

POLLUTION EPISODIC MODEL (PEM-2)

INPUT AREA SOURCE PARAMETERS: PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES

AREA SOURCE NUMBER	COORDINATES X(KM)	COORDINATES Y(KM)	LENGTH OF SIDE (M)	POLLUTANT-1 EMISSION RATE INPUT (G/S)	POLLUTANT-1 EMISSION RATE SCALED	POLLUTANT-2 EMISSION RATE INPUT (G/S)	POLLUTANT-2 EMISSION RATE SCALED
SUMS OF THE AREA SOURCE EMISSION RATES				0.0	0.0	0.0	0.0

EFFECTIVE HEIGHT OF THE AREA SOURCE EMISSIONS = 0.0 M

POLLUTION EPISODIC MODEL (PEM-2)

INPUT POINT SOURCE PARAMETERS: PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES

POINT SOURCE NUMBER	LABEL	COORDINATES X(KM)	Y(KM)	EMISSION RATE POLLUTANT-1 (G/S)	EMISSION RATE POLLUTANT-2 (G/S)	HEIGHT (M)	DIAMETER (M)	EXIT VEL (M/S)	EXIT TEMP (DEG C)
1	STACK 1	30.00	2.00	1000.000	50.000	200.00	5.000	10.000	450.0
2	STACK 2	10.00	2.00	500.000	25.000	200.00	4.000	8.000	400.0

SUMS OF THE POINT SOURCE EMISSION RATES 1500.000 G/S 75.000 G/S

INPUT CONTROL PARAMETERS:

WIND PROFILE EXPONENTS OPTION: NWPOPT=0
0 EXPONENTS AND ANEMOMETER HEIGHT ARE STANDARD DEFAULT VALUES
1 EXPONENTS AND ANEMOMETER HEIGHT TO BE SPECIFIED BY THE USER

STACK-TIP DOWNWASH ALGORITHM OPTION: NSTDWN=0
0 ALGORITHM IS IN EFFECT
1 ALGORITHM IS NOT USED

NEW PLUME-RISE EQUATIONS OPTION: NPRISE=1
0 STANDARD PLUME-RISE EQS. ARE USED FOR ALL STABILITY CLASSES
1 NEW EQS. ARE USED FOR PEAK BUOYANCY RISE FOR STABILITY CLASSES A-D

POTENTIAL TEMPERATURE GRADIENT: DTDZ(1)= 0.020 DEG/M STABILITY CLASS E
DTDZ(2)= 0.035 DEG/M STABILITY CLASS F

PLUME PENETRATION ABOVE MIXING HEIGHT OPTION: NINPEN=1
0 STANDARD TREATMENT OF PLUME PENETRATION ABOVE THE MIXING HEIGHT
1 NEW SCHEMES FOR PLUME PENETRATION OF ELEVATED STABLE LAYER USED
FOR STABILITY CLASSES A-D AND BUOYANCY-DOMINATED PLUME

OUTPUT OPTIONS SELECTED:

NPRINT=1 LIST OF POINT SOURCE PARAMETERS AND EFFECTIVE STACK HEIGHTS
PRINTED AT BEGINNING OF EACH SCENARIO

FINAL EFFECTIVE PLUME RISE USED: NGPR =1
BOUYANCY INDUCED DISPERSION FOR NBID=1: NBID= 0

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES

SCENARIO 1 POINT SOURCE PLUME RISE CALCULATIONS
MIXING HEIGHT: HMIX= 550.00 M
POTENTIAL TEMPERATURE GRADIENT ABOVE MIXING HEIGHT=0.0010 DEG/M

POINT SOURCE	SOURCE COORDINATES X(KM)	Y(KM)	EMISSION RATES POL-1 (G/S)	POL-2 (G/S)	STACK HEIGHT (M)	EXIT DIAMETER (M)	EXIT VELOCITY (M/S)	EXIT TEMP. (DEG K)	DOMINANT INFLUENCE	WIND SPEED AT STACK HEIGHT (M/S)	MAX.EFF. SOURCE HT. (M)	PLUME PENETRATION FRACTION
1	30.0	2.0	550.4	27.5	200.0	5.00	10.00	723.15	BUOYANCY	5.20	458.30	0.450
2	10.0	2.0	418.3	20.9	200.0	4.00	8.00	673.15	BUOYANCY	5.20	440.47	0.163

PEM-2 OUTPUT: SECTION 1 OF 1, SCENARIO 1 PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES
STABILITY=D , WIND SPD= 2.46 M/S, WIND DIR=180.00 DEG, MIXING HT= 550.0 M, AVERAGING TIME= 1 HR. POLLUTANT-1: SO2
UNCALIBRATED CONCENTRATION - MICROGRAMS PER CUBIC METER

	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00
48.00	0	0	0	1	11	23	11	1	0	0	0	0	0	2	15	31	15	2	0	0	0	0	0	0	0
46.00	0	0	0	1	11	24	11	1	0	0	0	0	0	2	15	32	15	2	0	0	0	0	0	0	0
44.00	0	0	0	1	11	25	11	1	0	0	0	0	0	1	15	33	15	1	0	0	0	0	0	0	0
42.00	0	0	0	1	11	26	11	1	0	0	0	0	0	1	15	34	15	1	0	0	0	0	0	0	0
40.00	0	0	0	1	11	27	11	1	0	0	0	0	0	1	15	36	15	1	0	0	0	0	0	0	0
38.00	0	0	0	1	11	28	11	1	0	0	0	0	0	1	15	37	15	1	0	0	0	0	0	0	0
36.00	0	0	0	1	11	30	11	1	0	0	0	0	0	1	15	39	15	1	0	0	0	0	0	0	0
34.00	0	0	0	0	11	31	11	0	0	0	0	0	0	1	14	41	14	1	0	0	0	0	0	0	0
32.00	0	0	0	0	11	33	11	0	0	0	0	0	0	0	14	43	14	0	0	0	0	0	0	0	0
30.00	0	0	0	0	10	34	10	0	0	0	0	0	0	0	13	45	13	0	0	0	0	0	0	0	0
28.00	0	0	0	0	10	36	10	0	0	0	0	0	0	0	13	48	13	0	0	0	0	0	0	0	0
26.00	0	0	0	0	9	39	9	0	0	0	0	0	0	0	12	51	12	0	0	0	0	0	0	0	0
24.00	0	0	0	0	8	41	8	0	0	0	0	0	0	0	11	54	11	0	0	0	0	0	0	0	0
22.00	0	0	0	0	8	44	8	0	0	0	0	0	0	0	10	58	10	0	0	0	0	0	0	0	0
20.00	0	0	0	0	7	47	7	0	0	0	0	0	0	0	9	62	9	0	0	0	0	0	0	0	0
18.00	0	0	0	0	5	51	5	0	0	0	0	0	0	0	7	68	7	0	0	0	0	0	0	0	0
16.00	0	0	0	0	4	56	4	0	0	0	0	0	0	0	5	74	5	0	0	0	0	0	0	0	0
14.00	0	0	0	0	3	63	3	0	0	0	0	0	0	0	4	82	4	0	0	0	0	0	0	0	0
12.00	0	0	0	0	1	71	1	0	0	0	0	0	0	0	2	93	2	0	0	0	0	0	0	0	0
10.00	0	0	0	0	0	83	0	0	0	0	0	0	0	0	1	109	1	0	0	0	0	0	0	0	0
8.00	0	0	0	0	0	101	0	0	0	0	0	0	0	0	0	133	0	0	0	0	0	0	0	0	0
6.00	0	0	0	0	0	105	0	0	0	0	0	0	0	0	0	133	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	0	64	0	0	0	0	0	0	0	0	0	72	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00

PEM-2 OUTPUT: SECTION 1 OF 1, SCENARIO 1 PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES
STABILITY=D , WIND SPD= 2.46 M/S, WIND DIR=180.00 DEG, MIXING HT= 550.0 M, AVERAGING TIME= 1 HR. POLLUTANT-1: SO2
UNCALIBRATED SURFACE DEPOSITION FLUX - KILOGRAMS PER SQUARE KILOMETER PER HOUR

	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00
48.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0
46.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0
44.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0
42.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0
40.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0
38.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0
36.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0
34.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0
32.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0
30.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0
28.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0
26.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0
24.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0
22.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0
20.00	0	0	0	0	0	3	0	0	0	0	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0
18.00	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1	5	1	0	0	0	0	0	0	0	0
16.00	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
14.00	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0
12.00	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
10.00	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0
8.00	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
6.00	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00

PEM-2 OUTPUT: SECTION 1 OF 1, SCENARIO 1 PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES
STABILITY=D, WIND SPD= 2.46 M/S, WIND DIR=180.00 DEG, MIXING HT= 550.0 M, AVERAGING TIME= 1 HR. POLLUTANT-2: SULFATE
UNCALIBRATED CONCENTRATION - MICROGRAMS PER CUBIC METER

	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00
48.00	0	0	0	1	6	12	6	1	0	0	0	0	0	1	8	15	8	1	0	0	0	0	0	0	0
46.00	0	0	0	1	5	12	5	1	0	0	0	0	0	1	7	15	7	1	0	0	0	0	0	0	0
44.00	0	0	0	0	5	11	5	0	0	0	0	0	0	1	7	15	7	1	0	0	0	0	0	0	0
42.00	0	0	0	0	5	11	5	0	0	0	0	0	0	1	7	15	7	1	0	0	0	0	0	0	0
40.00	0	0	0	0	5	11	5	0	0	0	0	0	0	0	6	15	6	0	0	0	0	0	0	0	0
38.00	0	0	0	0	4	11	4	0	0	0	0	0	0	0	6	15	6	0	0	0	0	0	0	0	0
36.00	0	0	0	0	4	11	4	0	0	0	0	0	0	0	5	15	5	0	0	0	0	0	0	0	0
34.00	0	0	0	0	4	11	4	0	0	0	0	0	0	0	5	14	5	0	0	0	0	0	0	0	0
32.00	0	0	0	0	4	11	4	0	0	0	0	0	0	0	5	14	5	0	0	0	0	0	0	0	0
30.00	0	0	0	0	3	11	3	0	0	0	0	0	0	0	4	14	4	0	0	0	0	0	0	0	0
28.00	0	0	0	0	3	11	3	0	0	0	0	0	0	0	4	14	4	0	0	0	0	0	0	0	0
26.00	0	0	0	0	2	10	2	0	0	0	0	0	0	0	3	14	3	0	0	0	0	0	0	0	0
24.00	0	0	0	0	2	10	2	0	0	0	0	0	0	0	3	14	3	0	0	0	0	0	0	0	0
22.00	0	0	0	0	2	10	2	0	0	0	0	0	0	0	2	13	2	0	0	0	0	0	0	0	0
20.00	0	0	0	0	1	10	1	0	0	0	0	0	0	0	2	13	2	0	0	0	0	0	0	0	0
18.00	0	0	0	0	1	10	1	0	0	0	0	0	0	0	1	13	1	0	0	0	0	0	0	0	0
16.00	0	0	0	0	1	10	1	0	0	0	0	0	0	0	1	13	1	0	0	0	0	0	0	0	0
14.00	0	0	0	0	0	10	0	0	0	0	0	0	0	0	1	13	1	0	0	0	0	0	0	0	0
12.00	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0
10.00	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0
8.00	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0
6.00	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00

PEM-2 OUTPUT: SECTION 1 OF 1, SCENARIO 1 PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES
STABILITY=D, WIND SPD= 2.46 M/S, WIND DIR=180.00 DEG, MIXING HT= 550.0 M, AVERAGING TIME= 1 HR. POLLUTANT-2: SULFATE
UNCALIBRATED SURFACE DEPOSITION FLUX - MICROGRAMS PER SQUARE METER PER HOUR

	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00
48.00	0	0	0	12	103	210	103	12	0	0	0	0	0	16	135	277	135	16	0	0	0	0	0	0	0
46.00	0	0	0	10	98	209	98	10	0	0	0	0	0	14	130	274	130	14	0	0	0	0	0	0	0
44.00	0	0	0	9	94	207	94	9	0	0	0	0	0	12	124	272	124	12	0	0	0	0	0	0	0
42.00	0	0	0	7	89	205	89	7	0	0	0	0	0	10	118	270	118	10	0	0	0	0	0	0	0
40.00	0	0	0	6	85	203	85	6	0	0	0	0	0	8	111	267	111	8	0	0	0	0	0	0	0
38.00	0	0	0	5	80	201	80	5	0	0	0	0	0	6	105	265	105	6	0	0	0	0	0	0	0
36.00	0	0	0	4	74	199	74	4	0	0	0	0	0	5	98	262	98	5	0	0	0	0	0	0	0
34.00	0	0	0	3	69	197	69	3	0	0	0	0	0	4	91	260	91	4	0	0	0	0	0	0	0
32.00	0	0	0	2	63	195	63	2	0	0	0	0	0	3	83	257	83	3	0	0	0	0	0	0	0
30.00	0	0	0	1	57	193	57	1	0	0	0	0	0	2	75	254	75	2	0	0	0	0	0	0	0
28.00	0	0	0	1	51	191	51	1	0	0	0	0	0	1	67	251	67	1	0	0	0	0	0	0	0
26.00	0	0	0	1	45	189	45	1	0	0	0	0	0	1	59	248	59	1	0	0	0	0	0	0	0
24.00	0	0	0	0	38	186	38	0	0	0	0	0	0	0	50	245	50	0	0	0	0	0	0	0	0
22.00	0	0	0	0	32	184	32	0	0	0	0	0	0	0	42	242	42	0	0	0	0	0	0	0	0
20.00	0	0	0	0	25	182	25	0	0	0	0	0	0	0	33	240	33	0	0	0	0	0	0	0	0
18.00	0	0	0	0	19	180	19	0	0	0	0	0	0	0	25	237	25	0	0	0	0	0	0	0	0
16.00	0	0	0	0	13	179	13	0	0	0	0	0	0	0	17	235	17	0	0	0	0	0	0	0	0
14.00	0	0	0	0	8	178	8	0	0	0	0	0	0	0	10	234	10	0	0	0	0	0	0	0	0
12.00	0	0	0	0	4	178	4	0	0	0	0	0	0	0	5	235	5	0	0	0	0	0	0	0	0
10.00	0	0	0	0	1	181	1	0	0	0	0	0	0	0	1	238	1	0	0	0	0	0	0	0	0
8.00	0	0	0	0	0	189	0	0	0	0	0	0	0	0	0	249	0	0	0	0	0	0	0	0	0
6.00	0	0	0	0	0	165	0	0	0	0	0	0	0	0	0	210	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	0	79	0	0	0	0	0	0	0	0	0	89	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES

HIGHEST PREDICTED CONCENTRATION OF EACH POLLUTANT FOR EACH SCENARIO OR AVERAGING PERIOD

UNCALIBRATED CONCENTRATION IN MICROGRAMS PER CUBIC METER - CALIBRATION, POLLUTANT-1:
CALIBRATION, POLLUTANT-2:

		POLLUTANT-1: SO2				POLLUTANT-2: SULFATE			
SCENARIO NUMBER	WIND DIRECTION SUB-SCENARIO	COORDINATES X(KM)	Y(KM)	CONCENTRATION UNCALIBRATED	CALIBRATED	COORDINATES X(KM)	Y(KM)	CONCENTRATION UNCALIBRATED	CALIBRATED
1		30.00	6.00	133.3774	0.0	30.00	48.00	15.3673	0.0

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 2A: 2 POINT SOURCES, NEW PLUME RISE & PENETRATION SCHEMES

HIGHEST PREDICTED SURFACE DEPOSITION FLUX OF EACH POLLUTANT FOR EACH SCENARIO OR AVERAGING PERIOD

UNCALIBRATED VALUES IN MICROGRAMS PER SQUARE METER PER HOUR - CALIBRATION, POLLUTANT-1:
CALIBRATION, POLLUTANT-2:

		POLLUTANT-1: SO2				POLLUTANT-2: SULFATE			
SCENARIO NUMBER	WIND DIRECTION SUB-SCENARIO	COORDINATES X(KM)	Y(KM)	SURFACE DEPOSITION FLUX UNCALIBRATED	CALIBRATED	COORDINATES X(KM)	Y(KM)	SURFACE DEPOSITION FLUX UNCALIBRATED	CALIBRATED
1		30.00	6.00	9603.1719	0.0	30.00	48.00	276.6121	0.0

TABLE E-5

INPUT DATA FOR EXAMPLE PROBLEM 2B

CARD IMAGES

```
CONTROL CARDS
1  TITLE   PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES
2  OPTIONS    1   1   1   0   1   0   2   0   0   1   0   0   0   1   1   1   1   0
3  GRID            0.        0.        25        25        2.        0.        0.
4  POLLUTANTS  2   1.        2.        0.       0.5       0.2       10.       1.5
5  SCALING         0.        1.        1.        0.        0.        0.        0.
6  LABLES  SO2                                     SULFATE
SCENARIO CARDS
               4   2.   9       0.        0.        25.       550.    0.001
            (A BLANK CARD TO SIGNAL END OF AREA SOURCE INVENTORY)
POINT SOURCE CARDS
          30.      2.    1000.      50.       200.        5.      10.     450. STACK 1
          10.      2.     500.      25.       200.        4.       8.     400. STACK 2
     (A BLANK CARD TO SIGNAL END OF POINT SOURCE INVENTORY)
```

TABLE E-6

OUTPUT LISTING FOR EXAMPLE PROBLEM 2B

PEM-2 (VERSION 84130)

POLLUTION EPISODIC MODEL

INCLUDING

DEPOSITION, SEDIMENTATION, AND CHEMICAL TRANSFORMATION

OF POLLUTANTS

POLLUTION EPISODIC MODEL (PEM-2)

INPUT CONTROL PARAMETERS: PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES

AVERAGING TIME OPTION: NTOPT=1

A SCENARIO IS A SET OF METEOROLOGICAL DATA FOR ONE HOUR

1 1 HOUR: CONCENTRATIONS ARE CALCULATED FOR EACH SCENARIO
2 24 HOURS: CONCENTRATIONS CALCULATED FOR 24 SCENARIOS ARE AVERAGED
3 VARIABLE: CONCENTRATIONS CALCULATED FOR A GIVEN NUMBER (2 TO 23) OF SCENARIOS ARE AVERAGED

WIND DIRECTION OPTION: NWDOPT=1

0 DIRECTION IN DEGREES TO BE SPECIFIED FOR EACH SCENARIO
1 SECTOR NUMBER TO BE SPECIFIED FOR EACH SCENARIO
2-7 DIRECTION IN DEGREES TO BE SPECIFIED FOR THE FIRST OF FOUR SUB-SCENARIOS.
FOR EACH SUCCEEDING SUB-SCENARIO, WIND DIRECTION IS AUTOMATICALLY INCREASED
BY 90,45,30,15,10,OR 5 DEGREES, DEPENDING ON THE OPTION NUMBER SELECTED.

WIND SPEED OPTION: NWSOPT=1

0 SPEED IN M/S TO BE SPECIFIED FOR EACH SCENARIO
1 WIND SPEED CLASS NUMBER TO BE SPECIFIED FOR EACH SCENARIO

NUMBER OF SCENARIOS: NSCEN= 1

RECEPTOR GRID: COLUMNS: LX= 25 ROWS: LY= 25
SPACING: GRID= 2.000 KM
SOUTHWEST CORNER XRSWC= 0.0 KM W
YRSWC= 0.0 KM S

POLLUTION EPISODIC MODEL (PEM-2)

INPUT CONTROL PARAMETERS: PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES

NUMBER OF POLLUTANTS: NPOL=2

	POLLUTANT-1: SO2	POLLUTANT-2: SULFATE
AREA SOURCE SCALING FACTOR:	ASCALE= 1.000	ASCALE= 1.000
CALIBRATION COEFFICIENTS:	A= 0.0 B= 0.0	A= 0.0 B= 0.0
CALIBRATION IDENTIFICATION:		
DEPOSITION VELOCITY (CM/S):	VD1= 2.000	VD2= 0.500
SETTLING VELOCITY (CM/S):	W1= 0.0	W2= 0.200

CHEMICAL TRANSFORMATION OPTION: ICT=1

NPOL=2
ICT=0 CHEMICAL TRANSFORMATION LOSS OF POLLUTANTS IS IGNORED
ICT=1 FIRST-ORDER CHEMICAL TRANSFORMATION OF POLLUTANT-1 TO POLLUTANT-2 IS CONSIDERED

CHEMICAL TRANSFORMATION OR DECAY RATE: XKT= 10.000 PERCENT/HR

RATIO OF MOLECULAR WEIGHTS OF POLLUTANT-2 (PRODUCT) TO POLLUTANT-1 (REACTANT): GAMMA= 1.500

OUTPUT OPTIONS SELECTED:

NARRAY=2 MAPS OF CONCENTRATION AND SURFACE DEPOSITION FLUX AT EACH RECEPTOR IN THE GRID, UNCALIBRATED ONLY
NMAX=1 LIST OF RECEPTORS WITH HIGHEST CONCENTRATION AND SURFACE DEPOSITION FLUX FOR EACH SCENARIO - PRINTED AT END OF RUN

POLLUTION EPISODIC MODEL (PEM-2)

INPUT SCENARIO PARAMETERS: PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES

WIND DIRECTIONS

SECTOR NUMBER	DIRECTION	(DEG)	SECTOR NUMBER	DIRECTION	(DEG)
1	N	0.0	9	S	180.0
2	NNE	22.5	10	SSW	202.5
3	NE	45.0	11	SW	225.0
4	ENE	67.5	12	WSW	247.5
5	E	90.0	13	W	270.0
6	ESE	112.5	14	WNW	292.5
7	SE	135.0	15	NW	315.0
8	SSE	157.5	16	NNW	337.5

WIND SPEED CLASSES

CLASS INDEX	SPEED (M/S)	CLASS INTERVAL(KT)
1	1.50	0-3
2	2.46	4-6
3	4.47	7-10
4	6.93	11-16
5	9.61	17-21
6	12.52	OVER 21

STABILITY CLASSES

CLASS INDEX	CLASS
1	A
2	B
3	C
4	D
5	E
6	F

SCENARIO NUMBER	STABILITY CLASS	WIND SPEED CLASS	WIND SPEED (M/S)	WIND SECTOR	WIND DIRECTION (DEG)	AMBIENT TEMPERATURE (DEG C)	TEMP GRADIENT ABOVE MIXING HEIGHT (DEG/M)	MIXING HEIGHT (M)
1	D	2		9		25.00		550.0

POLLUTION EPISODIC MODEL (PEM-2)

INPUT AREA SOURCE PARAMETERS: PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES

AREA SOURCE NUMBER	COORDINATES X(KM)	COORDINATES Y(KM)	LENGTH OF SIDE (M)	POLLUTANT-1 EMISSION RATE INPUT (G/S)	POLLUTANT-1 EMISSION RATE SCALED	POLLUTANT-2 EMISSION RATE INPUT (G/S)	POLLUTANT-2 EMISSION RATE SCALED
SUMS OF THE AREA SOURCE EMISSION RATES				0.0	0.0	0.0	0.0

EFFECTIVE HEIGHT OF THE AREA SOURCE EMISSIONS = 0.0 M

POLLUTION EPISODIC MODEL (PEM-2)

INPUT POINT SOURCE PARAMETERS: PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES

POINT SOURCE NUMBER	LABEL	COORDINATES X(KM)	Y(KM)	EMISSION RATE POLLUTANT-1 (G/S)	EMISSION RATE POLLUTANT-2 (G/S)	HEIGHT (M)	DIAMETER (M)	EXIT VEL (M/S)	EXIT TEMP (DEG C)
1	STACK 1	30.00	2.00	1000.000	50.000	200.00	5.000	10.000	450.000
2	STACK 2	10.00	2.00	500.000	25.000	200.00	4.000	8.000	400.000

SUMS OF THE POINT SOURCE EMISSION RATES 1500.000 G/S 75.000 G/S

INPUT CONTROL PARAMETERS:

WIND PROFILE EXPONENTS OPTION: NWPOPT=0
0 EXPONENTS AND ANEMOMETER HEIGHT ARE STANDARD DEFAULT VALUES
1 EXPONENTS AND ANEMOMETER HEIGHT TO BE SPECIFIED BY THE USER

STACK-TIP DOWNWASH ALGORITHM OPTION: NSTDWN=0
0 ALGORITHM IS IN EFFECT
1 ALGORITHM IS NOT USED

NEW PLUME-RISE EQUATIONS OPTION: NPRISE=0
0 STANDARD PLUME-RISE EQS. ARE USED FOR ALL STABILITY CLASSES
1 NEW EQS. ARE USED FOR PEAK BUOYANCY RISE FOR STABILITY CLASSES A-D

POTENTIAL TEMPERATURE GRADIENT: DTDZ(1)= 0.020 DEG/M STABILITY CLASS E
DTDZ(2)= 0.035 DEG/M STABILITY CLASS F

PLUME PENETRATION ABOVE MIXING HEIGHT OPTION: NINPEN=0
0 STANDARD TREATMENT OF PLUME PENETRATION ABOVE THE MIXING HEIGHT
1 NEW SCHEMES FOR PLUME PENETRATION OF ELEVATED STABLE LAYER USED
FOR STABILITY CLASSES A-D AND BUOYANCY-DOMINATED PLUME

OUTPUT OPTIONS SELECTED:

NPRINT=1 LIST OF POINT SOURCE PARAMETERS AND EFFECTIVE STACK HEIGHTS
PRINTED AT BEGINNING OF EACH SCENARIO

FINAL EFFECTIVE PLUME RISE USED: NGPR =1
BOUYANCY INDUCED DISPERSION FOR NBID=1: NBID = 0

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES

SCENARIO 1 POINT SOURCE PLUME RISE CALCULATIONS
MIXING HEIGHT: HMIX= 550.00 M

POINT SOURCE	SOURCE COORDINATES X(KM)	Y(KM)	EMISSION RATES POL-1 (G/S)	POL-2 (G/S)	HEIGHT (M)	DIAMETER (M)	EXIT VEL (M/S)	EXIT TEMP (DEG K)	DOMINANT INFLUENCE	WIND SPEED AT STACK HEIGHT (M/S)	MAXIMUM EFFECTIVE SOURCE HT (M)
1	30.00	2.00	1000.00	50.00	200.00	5.000	10.000	723.15	BUOYANCY	5.202	454.32
2	10.00	2.00	500.00	25.00	200.00	4.000	8.000	673.15	BUOYANCY	5.202	364.82

PEM-2 OUTPUT: SECTION 1 OF 1, SCENARIO 1 PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES
STABILITY=D , WIND SPD= 2.46 M/S, WIND DIR=180.00 DEG, MIXING HT= 550.0 M, AVERAGING TIME= 1 HR. POLLUTANT-1: SO2
UNCALIBRATED CONCENTRATION - MICROGRAMS PER CUBIC METER

	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00
48.00	0	0	0	2	14	28	14	2	0	0	0	0	0	3	27	56	27	3	0	0	0	0	0	0	0
46.00	0	0	0	1	14	29	14	1	0	0	0	0	0	3	27	58	27	3	0	0	0	0	0	0	0
44.00	0	0	0	1	14	30	14	1	0	0	0	0	0	3	27	60	27	3	0	0	0	0	0	0	0
42.00	0	0	0	1	14	31	14	1	0	0	0	0	0	2	27	62	27	2	0	0	0	0	0	0	0
40.00	0	0	0	1	14	33	14	1	0	0	0	0	0	2	27	65	27	2	0	0	0	0	0	0	0
38.00	0	0	0	1	13	34	13	1	0	0	0	0	0	2	27	68	27	2	0	0	0	0	0	0	0
36.00	0	0	0	1	13	35	13	1	0	0	0	0	0	1	26	71	26	1	0	0	0	0	0	0	0
34.00	0	0	0	1	13	37	13	1	0	0	0	0	0	1	26	74	26	1	0	0	0	0	0	0	0
32.00	0	0	0	0	13	39	13	0	0	0	0	0	0	1	25	78	25	1	0	0	0	0	0	0	0
30.00	0	0	0	0	12	41	12	0	0	0	0	0	0	1	24	82	24	1	0	0	0	0	0	0	0
28.00	0	0	0	0	12	43	12	0	0	0	0	0	0	0	23	87	23	0	0	0	0	0	0	0	0
26.00	0	0	0	0	11	46	11	0	0	0	0	0	0	0	22	92	22	0	0	0	0	0	0	0	0
24.00	0	0	0	0	10	49	10	0	0	0	0	0	0	0	20	98	20	0	0	0	0	0	0	0	0
22.00	0	0	0	0	9	53	9	0	0	0	0	0	0	0	18	105	18	0	0	0	0	0	0	0	0
20.00	0	0	0	0	8	57	8	0	0	0	0	0	0	0	16	113	16	0	0	0	0	0	0	0	0
18.00	0	0	0	0	6	61	6	0	0	0	0	0	0	0	13	123	13	0	0	0	0	0	0	0	0
16.00	0	0	0	0	5	67	5	0	0	0	0	0	0	0	10	135	10	0	0	0	0	0	0	0	0
14.00	0	0	0	0	3	75	3	0	0	0	0	0	0	0	6	150	6	0	0	0	0	0	0	0	0
12.00	0	0	0	0	2	85	2	0	0	0	0	0	0	0	3	170	3	0	0	0	0	0	0	0	0
10.00	0	0	0	0	1	99	1	0	0	0	0	0	0	0	1	198	1	0	0	0	0	0	0	0	0
8.00	0	0	0	0	0	121	0	0	0	0	0	0	0	0	0	241	0	0	0	0	0	0	0	0	0
6.00	0	0	0	0	0	142	0	0	0	0	0	0	0	0	0	244	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	0	143	0	0	0	0	0	0	0	0	0	136	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00

PEM-2 OUTPUT: SECTION 1 OF 1, SCENARIO 1 PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES
STABILITY=D , WIND SPD= 2.46 M/S, WIND DIR=180.00 DEG, MIXING HT= 550.0 M, AVERAGING TIME= 1 HR. POLLUTANT-1: SO2
UNCALIBRATED SURFACE DEPOSITION FLUX - KILOGRAMS PER SQUARE KILOMETER PER HOUR

	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00
48.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	2	4	2	0	0	0	0	0	0	0	0
46.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	2	4	2	0	0	0	0	0	0	0	0
44.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	2	4	2	0	0	0	0	0	0	0	0
42.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	2	4	2	0	0	0	0	0	0	0	0
40.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	2	5	2	0	0	0	0	0	0	0	0
38.00	0	0	0	0	1	2	1	0	0	0	0	0	0	0	2	5	2	0	0	0	0	0	0	0	0
36.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	2	5	2	0	0	0	0	0	0	0	0
34.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	2	5	2	0	0	0	0	0	0	0	0
32.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	2	6	2	0	0	0	0	0	0	0	0
30.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	2	6	2	0	0	0	0	0	0	0	0
28.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	2	6	2	0	0	0	0	0	0	0	0
26.00	0	0	0	0	1	3	1	0	0	0	0	0	0	0	2	7	2	0	0	0	0	0	0	0	0
24.00	0	0	0	0	1	4	1	0	0	0	0	0	0	0	1	7	1	0	0	0	0	0	0	0	0
22.00	0	0	0	0	1	4	1	0	0	0	0	0	0	0	1	8	1	0	0	0	0	0	0	0	0
20.00	0	0	0	0	1	4	1	0	0	0	0	0	0	0	1	8	1	0	0	0	0	0	0	0	0
18.00	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1	9	1	0	0	0	0	0	0	0	0
16.00	0	0	0	0	0	5	0	0	0	0	0	0	0	0	1	10	1	0	0	0	0	0	0	0	0
14.00	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0
12.00	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0
10.00	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0
8.00	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0
6.00	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00

PEM-2 OUTPUT: SECTION 1 OF 1, SCENARIO 1 PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES
STABILITY=D, WIND SPD= 2.46 M/S, WIND DIR=180.00 DEG, MIXING HT= 550.0 M, AVERAGING TIME= 1 HR. POLLUTANT-2: SULFATE
UNCALIBRATED CONCENTRATION - MICROGRAMS PER CUBIC METER

	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00
48.00	0	0	0	1	7	14	7	1	0	0	0	0	0	2	14	28	14	2	0	0	0	0	0	0	0
46.00	0	0	0	1	7	14	7	1	0	0	0	0	0	1	13	28	13	1	0	0	0	0	0	0	0
44.00	0	0	0	1	6	14	6	1	0	0	0	0	0	1	12	27	12	1	0	0	0	0	0	0	0
42.00	0	0	0	0	6	14	6	0	0	0	0	0	0	1	12	27	12	1	0	0	0	0	0	0	0
40.00	0	0	0	0	6	13	6	0	0	0	0	0	0	1	11	27	11	1	0	0	0	0	0	0	0
38.00	0	0	0	0	5	13	5	0	0	0	0	0	0	1	11	27	11	1	0	0	0	0	0	0	0
36.00	0	0	0	0	5	13	5	0	0	0	0	0	0	1	10	26	10	1	0	0	0	0	0	0	0
34.00	0	0	0	0	5	13	5	0	0	0	0	0	0	0	9	26	9	0	0	0	0	0	0	0	0
32.00	0	0	0	0	4	13	4	0	0	0	0	0	0	0	8	26	8	0	0	0	0	0	0	0	0
30.00	0	0	0	0	4	13	4	0	0	0	0	0	0	0	8	26	8	0	0	0	0	0	0	0	0
28.00	0	0	0	0	3	13	3	0	0	0	0	0	0	0	7	25	7	0	0	0	0	0	0	0	0
26.00	0	0	0	0	3	13	3	0	0	0	0	0	0	0	6	25	6	0	0	0	0	0	0	0	0
24.00	0	0	0	0	3	12	3	0	0	0	0	0	0	0	5	25	5	0	0	0	0	0	0	0	0
22.00	0	0	0	0	2	12	2	0	0	0	0	0	0	0	4	24	4	0	0	0	0	0	0	0	0
20.00	0	0	0	0	2	12	2	0	0	0	0	0	0	0	3	24	3	0	0	0	0	0	0	0	0
18.00	0	0	0	0	1	12	1	0	0	0	0	0	0	0	3	24	3	0	0	0	0	0	0	0	0
16.00	0	0	0	0	1	12	1	0	0	0	0	0	0	0	2	24	2	0	0	0	0	0	0	0	0
14.00	0	0	0	0	1	12	1	0	0	0	0	0	0	0	1	24	1	0	0	0	0	0	0	0	0
12.00	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0
10.00	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0
8.00	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0
6.00	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0
4.00	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0
2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0		4.00		8.00		12.00		16.00		20.00		24.00		28.00		32.00		36.00		40.00		44.00		48.00

PEM-2 OUTPUT: SECTION 1 OF 1, SCENARIO 1 PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES
STABILITY=D, WIND SPD= 2.46 M/S, WIND DIR=180.00 DEG, MIXING HT= 550.0 M, AVERAGING TIME= 1 HR. POLLUTANT-2: SULFATE
UNCALIBRATED SURFACE DEPOSITION FLUX - MICROGRAMS PER SQUARE METER PER HOUR

	0.0	4.00	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00	48.00
48.00	0 0 0 14	123 251	123 14	0 0 0 0	1 29	246 503	246 29	1 0	0 0	0 0	0 0	0 0	0 0
46.00	0 0 0 12	118 249	118 12	0 0 0 0	1 25	235 499	235 25	1 0	0 0	0 0	0 0	0 0	0 0
44.00	0 0 0 11	112 247	112 11	0 0 0 0	0 21	225 494	225 21	0 0	0 0	0 0	0 0	0 0	0 0
42.00	0 0 0 9	107 245	107 9	0 0 0 0	0 18	214 490	214 18	0 0	0 0	0 0	0 0	0 0	0 0
40.00	0 0 0 7	101 243	101 7	0 0 0 0	0 15	202 486	202 15	0 0	0 0	0 0	0 0	0 0	0 0
38.00	0 0 0 6	95 241	95 6	0 0 0 0	0 12	190 481	190 12	0 0	0 0	0 0	0 0	0 0	0 0
36.00	0 0 0 5	89 238	89 5	0 0 0 0	0 9	178 476	178 9	0 0	0 0	0 0	0 0	0 0	0 0
34.00	0 0 0 3	82 236	82 3	0 0 0 0	0 7	165 472	165 7	0 0	0 0	0 0	0 0	0 0	0 0
32.00	0 0 0 3	75 233	75 3	0 0 0 0	0 5	151 467	151 5	0 0	0 0	0 0	0 0	0 0	0 0
30.00	0 0 0 2	68 231	68 2	0 0 0 0	0 4	137 461	137 4	0 0	0 0	0 0	0 0	0 0	0 0
28.00	0 0 0 1	61 228	61 1	0 0 0 0	0 2	122 456	122 2	0 0	0 0	0 0	0 0	0 0	0 0
26.00	0 0 0 1	54 225	54 1	0 0 0 0	0 1	107 451	107 1	0 0	0 0	0 0	0 0	0 0	0 0
24.00	0 0 0 0	46 223	46 0	0 0 0 0	0 1	92 446	92 1	0 0	0 0	0 0	0 0	0 0	0 0
22.00	0 0 0 0	38 220	38 0	0 0 0 0	0 0	76 440	76 0	0 0	0 0	0 0	0 0	0 0	0 0
20.00	0 0 0 0	30 218	30 0	0 0 0 0	0 0	60 436	60 0	0 0	0 0	0 0	0 0	0 0	0 0
18.00	0 0 0 0	23 216	23 0	0 0 0 0	0 0	45 431	45 0	0 0	0 0	0 0	0 0	0 0	0 0
16.00	0 0 0 0	15 214	15 0	0 0 0 0	0 0	31 428	31 0	0 0	0 0	0 0	0 0	0 0	0 0
14.00	0 0 0 0	9 213	9 0	0 0 0 0	0 0	18 426	18 0	0 0	0 0	0 0	0 0	0 0	0 0
12.00	0 0 0 0	4 213	4 0	0 0 0 0	0 0	9 427	9 0	0 0	0 0	0 0	0 0	0 0	0 0
10.00	0 0 0 0	1 217	1 0	0 0 0 0	0 0	3 433	3 0	0 0	0 0	0 0	0 0	0 0	0 0
8.00	0 0 0 0	0 226	0 0	0 0 0 0	0 0	0 452	0 0	0 0	0 0	0 0	0 0	0 0	0 0
6.00	0 0 0 0	0 223	0 0	0 0 0 0	0 0	0 384	0 0	0 0	0 0	0 0	0 0	0 0	0 0
4.00	0 0 0 0	0 176	0 0	0 0 0 0	0 0	0 167	0 0	0 0	0 0	0 0	0 0	0 0	0 0
2.00	0 0 0 0	0 0	0 0	0 0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
0.0	0 0 0 0	0 0	0 0	0 0 0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
	0.0	4.00	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00	48.00

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES

HIGHEST PREDICTED CONCENTRATION OF EACH POLLUTANT FOR EACH SCENARIO OR AVERAGING PERIOD

UNCALIBRATED CONCENTRATION IN MICROGRAMS PER CUBIC METER - CALIBRATION, POLLUTANT-1:
CALIBRATION, POLLUTANT-2:

		POLLUTANT-1: SO2				POLLUTANT-2: SULFATE			
SCENARIO NUMBER	WIND DIRECTION SUB-SCENARIO	COORDINATES X(KM)	Y(KM)	CONCENTRATION UNCALIBRATED	CALIBRATED	COORDINATES X(KM)	Y(KM)	CONCENTRATION UNCALIBRATED	CALIBRATED
1		30.00	6.00	244.1823	0.0	30.00	48.00	27.9226	0.0

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 2B: 2 POINT SOURCES, STANDARD PLUME RISE & PENETRATION SCHEMES

HIGHEST PREDICTED SURFACE DEPOSITION FLUX OF EACH POLLUTANT FOR EACH SCENARIO OR AVERAGING PERIOD

UNCALIBRATED VALUES IN MICROGRAMS PER SQUARE METER PER HOUR - CALIBRATION, POLLUTANT-1:
CALIBRATION, POLLUTANT-2:

		POLLUTANT-1: SO2				POLLUTANT-2: SULFATE			
SCENARIO NUMBER	WIND DIRECTION SUB-SCENARIO	COORDINATES X(KM)	Y(KM)	SURFACE DEPOSITION FLUX UNCALIBRATED	CALIBRATED	COORDINATES X(KM)	Y(KM)	SURFACE DEPOSITION FLUX UNCALIBRATED	CALIBRATED
1		30.00	6.00	17581.1211	0.0	30.00	48.00	502.6060	0.0

TABLE E-7

INPUT DATA FOR EXAMPLE PROBLEM 3

CARD IMAGES

```
CONTROL CARDS
1  TITLE   PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS
2  OPTIONS    3   0   0   1   6   0   2   0   0   1   1   0   0   1   0   1   1   0
3  GRID           0.        0.        25        25        1.5      0.015     0.030
4  POLLUTANTS  2   1        2.        0.        0.2        0.        5.0       1.5
5  SCALING        0.        1.        1.        0.        0.        0.        0.
6  LABELS  SO2                                     SULFATE
7  WIND PROFILE 15.    10.    200.     1.    0.20    0.20    0.25    0.30    0.35    0.35
SCENARIO CARDS
                5                 3.5       260.        5.       200.        0.
                5                 3.5       260.        5.       200.        0.
                5                 3.0       270.        1.       200.        0.
                6                 3.0       270.        1.       150.        0.
                6                 2.5       280.       -3.       150.        0.
                6                 2.5       280.       -3.       150.        0.
AREA SOURCE CARDS
                  0.75     15.75    4500.        75.        7.5
             (A BLANK CARD TO SIGNAL END OF AREA SOURCE INVENTORY)
POINT SOURCE CARDS
                3.0    18.0    100.       15.       30.        2.        4.     250. STACK 1
                1.5     7.5    200.       10.       50.        3.        5.     200. STACK 2
                1.5    28.5     60.        6.       10.        1.        2.     150. STACK 3
            (A BLANK CARD TO SIGNAL END OF POINT SOURCE INVENTORY)
```

TABLE E-8

OUTPUT LISTING FOR EXAMPLE PROBLEM 3

PEM-2 (VERSION 84130)

POLLUTION EPISODIC MODEL

INCLUDING

DEPOSITION, SEDIMENTATION, AND CHEMICAL TRANSFORMATION

OF POLLUTANTS

POLLUTION EPISODIC MODEL (PEM-2)

INPUT CONTROL PARAMETERS: PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS

AVERAGING TIME OPTION: NTOPT=3

A SCENARIO IS A SET OF METEOROLOGICAL DATA FOR ONE HOUR

1 1 HOUR: CONCENTRATIONS ARE CALCULATED FOR EACH SCENARIO
2 24 HOURS: CONCENTRATIONS CALCULATED FOR 24 SCENARIOS ARE AVERAGED
3 VARIABLE: CONCENTRATIONS CALCULATED FOR A GIVEN NUMBER (2 TO 23) OF SCENARIOS ARE AVERAGED

WIND DIRECTION OPTION: NWDOPT=0

0 DIRECTION IN DEGREES TO BE SPECIFIED FOR EACH SCENARIO
1 SECTOR NUMBER TO BE SPECIFIED FOR EACH SCENARIO
2-7 DIRECTION IN DEGREES TO BE SPECIFIED FOR THE FIRST OF FOUR SUB-SCENARIOS.
FOR EACH SUCCEEDING SUB-SCENARIO, WIND DIRECTION IS AUTOMATICALLY INCREASED
BY 90,45,30,15,10,OR 5 DEGREES, DEPENDING ON THE OPTION NUMBER SELECTED.

WIND SPEED OPTION: NWSOPT=0

0 SPEED IN M/S TO BE SPECIFIED FOR EACH SCENARIO
1 WIND SPEED CLASS NUMBER TO BE SPECIFIED FOR EACH SCENARIO

NUMBER OF SCENARIOS: NSCEN= 6

RECEPTOR GRID: COLUMNS: LX= 25 ROWS: LY= 25
SPACING: GRID= 1.500 KM
SOUTHWEST CORNER XRSWC= 0.0 KM W
YRSWC= 0.0 KM S

POLLUTION EPISODIC MODEL (PEM-2)

INPUT CONTROL PARAMETERS: PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS

NUMBER OF POLLUTANTS: NPOL=2

	POLLUTANT-1: SO2	POLLUTANT-2: SULFATE
AREA SOURCE SCALING FACTOR:	ASCALE= 1.000	ASCALE= 1.000
CALIBRATION COEFFICIENTS:	A= 0.0 B= 0.0	A= 0.0 B= 0.0
CALIBRATION IDENTIFICATION:		
DEPOSITION VELOCITY (CM/S):	VD1= 2.000	VD2= 0.200
SETTLING VELOCITY (CM/S):	W1= 0.0	W2= 0.0

CHEMICAL TRANSFORMATION OPTION: ICT=1

NPOL=2
ICT=0 CHEMICAL TRANSFORMATION LOSS OF POLLUTANTS IS IGNORED
ICT=1 FIRST-ORDER CHEMICAL TRANSFORMATION OF POLLUTANT-1 TO POLLUTANT-2 IS CONSIDERED

CHEMICAL TRANSFORMATION OR DECAY RATE: XKT= 5.000 PERCENT/HR

RATIO OF MOLECULAR WEIGHTS OF POLLUTANT-2 (PRODUCT) TO POLLUTANT-1 (REACTANT): GAMMA= 1.500

OUTPUT OPTIONS SELECTED:

NARRAY=2 MAPS OF CONCENTRATION AND SURFACE DEPOSITION FLUX AT EACH RECEPTOR IN THE GRID, UNCALIBRATED ONLY
NMAX=1 LIST OF RECEPTORS WITH HIGHEST CONCENTRATION AND SURFACE DEPOSITION FLUX FOR EACH SCENARIO - PRINTED AT END OF RUN

POLLUTION EPISODIC MODEL (PEM-2)

INPUT SCENARIO PARAMETERS: PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS

WIND DIRECTIONS

SECTOR NUMBER	DIRECTION	(DEG)	SECTOR NUMBER	DIRECTION	(DEG)
1	N	0.0	9	S	180.0
2	NNE	22.5	10	SSW	202.5
3	NE	45.0	11	SW	225.0
4	ENE	67.5	12	WSW	247.5
5	E	90.0	13	W	270.0
6	ESE	112.5	14	WNW	292.5
7	SE	135.0	15	NW	315.0
8	SSE	157.5	16	NNW	337.5

WIND SPEED CLASSES

CLASS INDEX	SPEED (M/S)	CLASS INTERVAL(KT)
1	1.50	0-3
2	2.46	4-6
3	4.47	7-10
4	6.93	11-16
5	9.61	17-21
6	12.52	OVER 21

STABILITY CLASSES

CLASS INDEX	CLASS
1	A
2	B
3	C
4	D
5	E
6	F

SCENARIO NUMBER	STABILITY CLASS	WIND SPEED CLASS	WIND SPEED (M/S)	WIND SECTOR	WIND DIRECTION (DEG)	AMBIENT TEMPERATURE (DEG C)	TEMP GRADIENT ABOVE MIXING HEIGHT (DEG/M)	MIXING HEIGHT (M)
1	E		3.500		260.00	5.00		200.0
2	E		3.500		260.00	5.00		200.0
3	E		3.000		270.00	1.00		200.0
4	F		3.000		270.00	1.00		150.0
5	F		2.500		280.00	-3.00		150.0
6	F		2.500		280.00	-3.00		150.0

POLLUTION EPISODIC MODEL (PEM-2)

INPUT AREA SOURCE PARAMETERS: PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS

AREA SOURCE NUMBER	COORDINATES X(KM)	COORDINATES Y(KM)	LENGTH OF SIDE (M)	POLLUTANT-1 EMISSION RATE INPUT (G/S)	POLLUTANT-1 EMISSION RATE SCALED	POLLUTANT-2 EMISSION RATE INPUT (G/S)	POLLUTANT-2 EMISSION RATE SCALED
1	0.75	15.75	4500.00	75.000	75.000	7.500	7.500
SUMS OF THE AREA SOURCE EMISSION RATES				75.000	75.000	7.500	7.500

EFFECTIVE HEIGHT OF THE AREA SOURCE EMISSIONS = 0.0 M

POLLUTION EPISODIC MODEL (PEM-2)

INPUT POINT SOURCE PARAMETERS: PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCERTRATIONS

POINT SOURCE NUMBER	LABEL	COORDINATES X(KM)	Y(KM)	EMISSION RATE POLLUTANT-1 (G/S)	EMISSION RATE POLLUTANT-2 (G/S)	HEIGHT (M)	DIAMETER (M)	EXIT VEL (M/S)	EXIT TP (DEG)
1	STACK 1	3.00	18.00	100.000	15.000	30.00	2.000	4.000	250.0
2	STACK 2	1.50	7.50	200.000	10.000	50.00	3.000	5.000	200.0
3	STACK 3	1.50	28.50	60.000	6.000	10.00	1.000	2.000	150.0

SUMS OF THE POINT SOURCE EMISSION RATES 360.000 G/S 31.000 G/S

INPUT CONTROL PARAMETERS:

WIND PROFILE EXPONENTS OPTION: NWPOPT=1
0 EXPONENTS AND ANEMOMETER HEIGHT ARE STANDARD DEFAULT VALUES
1 EXPONENTS AND ANEMOMETER HEIGHT TO BE SPECIFIED BY THE USER

USER SPECIFIED WIND PROFILE EXPONENT VALUES:
0.20 0.20 0.25 0.30 0.35 0.35
ANEMOMETER HEIGHT = 15.0 METERS HMIN = 10.0 ,HMAX = 200. ,UMIN = 1.0

STACK-TIP DOWNWASH ALGORITHM OPTION: NSTDWN=1
0 ALGORITHM IS IN EFFECT
1 ALGORITHM IS NOT USED

NEW PLUME-RISE EQUATIONS OPTION: NPRISE=0
0 STANDARD PLUME-RISE EQS. ARE USED FOR ALL STABILITY CLASSES
1 NEW EQS. ARE USED FOR PEAK BUOYANCY RISE FOR STABILITY CLASSES A-D

POTENTIAL TEMPERATURE GRADIENT: DTDZ(1)= 0.015 DEG/M STABILITY CLASS E
DTDZ(2)= 0.030 DEG/M STABILITY CLASS F

PLUME PENETRATION ABOVE MIXING HEIGHT OPTION: NINPEN=0
0 STANDARD TREATMENT OF PLUME PENETRATION ABOVE THE MIXING HEIGHT
1 NEW SCHEMES FOR PLUME PENETRATION OF ELEVATED STABLE LAYER USED
FOR STABILITY CLASSES A-D AND BUOYANCY-DOMINATED PLUME

FINAL EFFECTIVE PLUME RISE USED: NGPR=1
BOUYANCY INDUCED DISPERSION FOR NBID=1: NBID= 0

PEM-2 OUTPUT: SECTION 1 OF 1 PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS
6 SCENARIOS, AVERAGING TIME= 6 HRS. POLLUTANT-1: SO2
UNCALIBRATED CONCENTRATION - MICROGRAMS PER CUBIC METER

	0.0		3.00		6.00		9.00		12.00		15.00		18.00		21.00		24.00		27.00		30.00		33.00		36.00
36.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
34.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	5	5	5
33.00	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	5	6	7	7	6	5	4	3	2	2
31.50	0	0	0	0	0	0	0	0	1	4	7	9	10	9	7	5	4	2	1	1	1	0	0	0	0
30.00	0	0	0	0	2	12	19	17	12	8	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2
28.50	0	0	233	76	44	32	27	23	20	18	16	14	13	12	11	11	10	9	9	8	8	7	7	7	7
27.00	0	0	0	0	4	19	30	27	19	12	7	4	3	2	2	2	2	2	2	2	2	2	2	2	2
25.50	0	0	0	0	0	0	0	0	2	6	11	15	16	14	11	8	6	4	2	1	1	1	1	1	2
24.00	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	7	10	11	11	12	11	11	11	11	10
22.50	0	0	0	0	0	0	0	0	0	1	1	1	0	1	2	5	7	10	12	14	14	14	14	12	11
21.00	0	0	0	0	2	4	5	4	4	5	7	11	13	14	13	10	8	5	4	2	2	1	2	2	3
19.50	0	79	98	108	33	21	26	33	30	23	15	8	4	3	2	2	2	2	2	3	3	3	3	3	3
18.00	0	79	98	283	120	78	59	49	42	35	28	23	20	18	17	16	15	14	13	13	12	12	11	11	10
16.50	0	79	98	108	33	23	37	49	45	34	21	12	6	4	3	2	2	2	2	3	3	3	3	3	3
15.00	0	0	0	0	3	4	6	5	4	6	11	17	21	22	20	17	12	8	5	4	2	2	3	4	6
13.50	0	0	0	0	0	0	0	0	0	1	1	1	0	1	4	7	12	16	19	22	23	24	23	22	19
12.00	0	0	0	0	0	0	0	0	0	0	0	0	2	4	8	12	16	19	20	20	20	19	18	17	16
10.50	0	0	0	0	0	0	0	1	3	9	17	23	25	23	19	14	10	6	4	2	2	1	1	2	3
9.00	0	0	0	0	5	26	42	40	29	19	12	7	5	4	4	4	4	5	5	5	5	5	5	6	6
7.50	0	0	150	125	94	74	62	53	47	42	39	36	33	31	29	27	26	25	23	22	21	20	20	19	18
6.00	0	0	0	0	8	45	71	67	48	30	18	11	7	5	4	4	4	5	5	5	5	5	5	6	6
4.50	0	0	0	0	0	0	0	1	5	16	29	38	41	38	30	22	15	10	6	4	2	1	1	1	0
3.00	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	20	26	29	29	26	22	18	13	9	6
1.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	10	15	19	21	23	22
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	5	8
	0.0		3.00		6.00		9.00		12.00		15.00		18.00		21.00		24.00		27.00		30.00		33.00		36.00

PEM-2 OUTPUT: SECTION 1 OF 1 PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS

6 SCENARIOS, AVERAGING TIME= 6 HRS. POLLUTANT-1: SO2

UNCALIBRATED SURFACE DEPOSITION FLUX - KILOGRAMS PER SQUARE KILOMETER PER HOUR

	0.0		3.00		6.00		9.00		12.00		15.00		18.00		21.00		24.00		27.00		30.00		33.00		36.00
36.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
31.50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
30.00	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.50	0	0	17	5	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
27.00	0	0	0	0	0	1	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.50	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
24.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
22.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
21.00	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
19.50	0	6	7	8	2	1	2	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
18.00	0	6	7	20	9	6	4	4	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1
16.50	0	6	7	8	2	2	3	4	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
15.00	0	0	0	0	0	0	0	0	0	0	1	1	2	2	1	1	1	1	0	0	0	0	0	0	0
13.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	2	1
12.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
10.50	0	0	0	0	0	0	0	0	0	1	1	2	2	2	1	1	1	0	0	0	0	0	0	0	0
9.00	0	0	0	0	0	2	3	3	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7.50	0	0	11	9	7	5	4	4	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1
6.00	0	0	0	0	1	3	5	5	3	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
4.50	0	0	0	0	0	0	0	0	0	1	2	3	3	3	2	2	1	1	0	0	0	0	0	0	0
3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	2	2	2	1	1	1	0
1.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	0.0		3.00		6.00		9.00		12.00		15.00		18.00		21.00		24.00		27.00		30.00		33.00		36.00

PEM-2 OUTPUT: SECTION 1 OF 1 PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS
6 SCENARIOS, AVERAGING TIME= 6 HRS. POLLUTANT-2: SULFATE
UNCALIBRATED CONCENTRATION - MICROGRAMS PER CUBIC METER

	0.0		3.00		6.00		9.00		12.00		15.00		18.00		21.00		24.00		27.00		30.00		33.00		36.00
36.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
34.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3	3
33.00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3	3	3	2	2	1	1
31.50	0	0	0	0	0	0	0	0	0	1	2	3	3	3	3	2	1	1	1	0	0	0	0	0	0
30.00	0	0	0	0	0	2	4	4	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28.50	0	0	34	13	8	7	6	6	5	5	5	5	5	5	5	4	4	4	4	4	4	4	3	3	3
27.00	0	0	0	0	1	4	8	8	6	4	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1
25.50	0	0	0	0	0	0	0	0	1	2	4	6	7	6	5	4	3	2	1	1	0	0	0	1	1
24.00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	5	6	7	7	7	6	6	6	5
22.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	8	8	7
21.00	0	0	0	0	0	1	1	1	1	1	2	3	4	4	4	4	3	2	1	1	1	1	1	2	2
19.50	0	10	13	15	6	4	6	8	8	7	4	3	1	1	1	1	1	1	1	1	1	1	1	2	2
18.00	0	10	13	46	24	17	14	13	12	10	9	7	7	6	6	6	6	6	6	6	5	5	5	5	5
16.50	0	10	13	15	6	5	10	14	14	11	7	4	2	1	1	1	1	1	1	1	1	1	1	2	2
15.00	0	0	0	0	1	1	2	2	2	2	4	6	8	9	8	7	5	4	3	2	1	1	1	1	1
13.50	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	5	7	8	9	9	9	8	8	7
12.00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	3	4	4	5	6	7	8	8	8
10.50	0	0	0	0	0	0	0	0	0	1	2	3	4	4	3	2	2	1	1	1	0	0	1	1	2
9.00	0	0	0	0	0	2	4	4	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
7.50	0	0	9	9	8	7	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6.00	0	0	0	0	1	5	8	8	7	5	3	2	1	1	1	1	1	1	1	1	1	1	1	2	2
4.50	0	0	0	0	0	0	0	0	1	2	5	7	8	8	6	5	4	3	2	1	1	0	0	0	0
3.00	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	5	6	7	8	7	6	5	4	3	2
1.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	6	7	7	8
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3
	0.0		3.00		6.00		9.00		12.00		15.00		18.00		21.00		24.00		27.00		30.00		33.00		36.00

PEM-2 OUTPUT: SECTION 1 OF 1 PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS

6 SCENARIOS, AVERAGING TIME= 6 HRS. POLLUTANT-2: SULFATE

UNCALIBRATED SURFACE DEPOSITION FLUX - MICROGRAMS PER SQUARE METER PER HOUR

	0.0		3.00		6.00		9.00		12.00		15.00		18.00		21.00		24.00		27.00		30.00		33.00		36.00
36.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	5	8
34.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	8	12	16	19	21	21
33.00	0	0	0	0	0	0	0	0	0	0	0	0	2	4	8	13	18	21	22	21	18	15	12	9	6
31.50	0	0	0	0	0	0	0	0	2	8	15	21	24	23	19	15	11	7	5	3	2	1	1	1	0
30.00	0	0	0	0	3	16	28	28	22	15	10	7	5	5	4	5	5	6	6	7	7	8	8	9	9
28.50	0	0	242	92	59	48	43	40	38	37	35	35	34	33	33	32	32	31	31	31	30	30	30	30	30
27.00	0	0	0	0	5	32	55	56	43	29	18	12	8	6	5	5	5	6	6	7	7	8	8	9	9
25.50	0	0	0	0	0	0	0	1	5	15	30	42	48	46	39	30	22	15	10	6	4	3	3	4	7
24.00	0	0	0	0	0	0	0	0	0	0	0	1	3	8	17	27	37	44	47	48	47	46	44	41	38
22.50	0	0	0	0	0	0	0	0	0	2	2	2	1	2	6	12	20	28	37	45	51	56	57	56	53
21.00	0	0	0	0	3	6	9	8	8	11	15	23	29	32	31	26	20	14	10	7	5	5	7	11	17
19.50	0	73	94	108	42	32	43	59	57	47	31	19	9	7	6	6	6	7	7	8	9	9	10	11	12
18.00	0	73	94	335	171	124	104	93	85	75	63	52	47	46	44	43	42	41	41	40	40	39	39	38	38
16.50	0	73	94	108	43	38	70	101	99	80	53	31	16	10	8	7	7	7	8	8	9	9	10	11	12
15.00	0	0	0	0	5	9	13	12	12	17	28	44	57	64	61	51	39	28	19	13	8	6	6	8	11
13.50	0	0	0	0	0	0	0	0	0	3	3	4	1	4	11	22	36	50	60	66	68	66	61	55	47
12.00	0	0	0	0	0	0	0	0	0	0	0	0	2	5	9	15	21	27	32	37	43	49	55	59	60
10.50	0	0	0	0	0	0	0	0	3	8	16	23	26	26	22	17	12	8	6	4	3	3	4	8	13
9.00	0	0	0	0	3	17	29	30	23	16	11	7	6	5	5	6	6	7	8	8	9	10	10	11	12
7.50	0	0	67	67	57	50	46	43	41	40	39	39	38	38	38	37	37	37	37	37	37	37	37	37	37
6.00	0	0	0	0	6	34	59	61	48	33	21	13	9	7	6	6	6	7	8	8	9	10	10	11	12
4.50	0	0	0	0	0	0	0	1	5	17	34	49	56	54	46	36	26	18	12	7	5	3	2	1	1
3.00	0	0	0	0	0	0	0	0	0	0	0	1	4	10	20	32	44	52	55	52	46	38	30	22	16
1.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	12	21	31	41	49	53	54
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	20
	0.0		3.00		6.00		9.00		12.00		15.00		18.00		21.00		24.00		27.00		30.00		33.00		36.00

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCENTRATIONS

HIGHEST PREDICTED CONCENTRATION OF EACH POLLUTANT FOR EACH SCENARIO OR AVERAGING PERIOD

UNCALIBRATED CONCENTRATION IN MICROGRAMS PER CUBIC METER - CALIBRATION, POLLUTANT-1:
CALIBRATION, POLLUTANT-2:

		POLLUTANT-1: SO2				POLLUTANT-2: SULFATE			
SCENARIO NUMBER	WIND DIRECTION SUB-SCENARIO	COORDINATES X(KM)	Y(KM)	CONCENTRATION UNCALIBRATED	CALIBRATED	COORDINATES X(KM)	Y(KM)	CONCENTRATION UNCALIBRATED	CALIBRATED
1		4.50	18.00	282.9429	0.0	4.50	18.00	46.4973	0.0

POLLUTION EPISODIC MODEL (PEM-2)

OUTPUT: PEM-2 EXAMPLE 3: 1 AREA SOURCE & 3 POINT SOURCES, 6-HR AVG CONCERTRATIONS

HIGHEST PREDICTED SURFACE DEPOSITION FLUX OF EACH POLLUTANT FOR EACH SCENARIO OR AVERAGING PERIOD

UNCALIBRATED VALUES IN MICROGRAMS PER SQUARE METER PER HOUR - CALIBRATION, POLLUTANT-1:
CALIBRATION, POLLUTANT-2:

		POLLUTANT-1: SO2				POLLUTANT-2: SULFATE			
SCENARIO NUMBER	WIND DIRECTION SUB-SCENARIO	COORDINATES X(KM)	Y(KM)	SURFACE DEPOSITION FLUX UNCALIBRATED	CALIBRATED	COORDINATES X(KM)	Y(KM)	SURFACE DEPOSITION FLUX UNCALIBRATED	CALIBRATED
1		4.50	18.00	20371.8892	0.0	4.50	18.00	334.7804	0.0

APPENDIX F

PEM-2 FORTRAN LISTING

The PEM-2 (Version 84130) computer program was developed and tested on an IBM computer at the Oak Ridge National Laboratory. The program was later modified slightly to run on a UNIVAC 1100 computer at Research Triangle Park. A listing of the UNIVAC-compatible FORTRAN program follows. The PEM-2 code is also contained on UNAMAP Version 6 magnetic tape available through the National Technical Information Service. The code listing printed herein should be used as the reference.

```
C
C
C                    PEM-2.0  (DATED 86016)
C                    AN AIR QUALITY DISPERSION MODEL IN
C                    SECTION 2. NON-GUIDELINE MODELS
C                    IN UNAMAP (VERSION 6) JULY 86.
C                    SOURCE:  UNAMAP FILE ON EPA'S UNIVAC AT RTP, NC.
C                                                                      PMT00010
C                                                                      PMT00020
C                                                                      PMT00030
C               *** PEM-2   (VERSION  84130) ***                       PMT00040
C                                                                      PMT00050
C                                                                      PMT00060
C                  POLLUTION EPISODIC MODEL                            PMT00070
C                          INCLUDING                                   PMT00080
C    DEPOSITION, SEDIMENTATION, AND CHEMICAL TRANSFORMATION            PMT00090
C                        OF POLLUTANTS                                 PMT00100
C                                                                      PMT00110
C                                                                      PMT00120
C *** PEM-2 PROGRAM DEVELOPMENT : --- MAY 1984                         PMT00130
C                                                                      PMT00140
C     K. SHANKAR RAO                                                   PMT00150
C     ATMOSPHERIC TURBULENCE AND DIFFUSION DIVISION   (ATDD)           PMT00160
C     NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)           PMT00170
C     U.S. DEPARTMENT OF COMMERCE                                      PMT00180
C     P.O. BOX - E                                                     PMT00190
C     OAK RIDGE, TENN 37831                                            PMT00200
C                                                                      PMT00210
C     PHONE: (615) 576-1238                                            PMT00220
C            FTS: 626-1238                                             PMT00230
C                                                                      PMT00240
C     ( THIS WORK WAS DONE UNDER AN INTERAGENCY AGREEMENT              PMT00250
C     BETWEEN THE ENVIRONMENTAL PROTECTION AGENCY AND THE              PMT00260
C     NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION )                PMT00270
C                                                                      PMT00280
C                                                                      PMT00290
C *** EXTENDED ABSTRACT : PEM-2 (VERSION 84130).                       PMT00300
C                                                                      PMT00310
C        THE POLLUTION EPISODIC MODEL (PEM) DESCRIBED BY RAO AND STEVENSPMT00320
C     (1982) IS AN URBAN SCALE (UP TO 50 KM DISTANCES) AIR POLLUTION   PMT00330
C     MODEL CAPABLE OF PREDICTING SHORT-TERM (1 TO 24-HOUR) AVERAGE    PMT00340
C     SURFACE CONCENTRATIONS AND DEPOSITION FLUXES OF TWO CHEMICALLY   PMT00350
C     COUPLED GASEOUS OR PARTICULATE POLLUTANTS AT UP TO A MAXIMUM OF  PMT00360
C     2500 GROUND-LEVEL RECEPTORS LOCATED ON A 50X50 SQUARE RECEPTOR   PMT00370
C     GRID. PREDICTIONS ARE BASED ON STEADY-STATE GAUSSIAN PLUME ASSUMP-PMT00380
C     TIONS, BRIGGS' PLUME RISE FORMULATIONS, AND PASQUILL-GIFFORD (PG) PMT00390
C     DISPERSION PARAMETERS.  THE SURFACE CONCENTRATION AND DEPOSITION PMT00400
C     FLUX ESTIMATES OF TWO INDEPENDENT NONREACTIVE (GASEOUS OR PARTICU-PMT00410
C     LATE) POLLUTANTS OR ONE POLLUTANT WITH FIRST-ORDER CHEMICAL DECAY PMT00420
C     CAN BE OBTAINED AS SPECIAL CASES OF THE MODEL.  UP TO 300 POINT  PMT00430
C     SOURCES AND UP TO 50 AREA SOURCES MAY BE INCLUDED IN THE MODEL   PMT00440
C     INPUTS.  CALCULATIONS ARE PERFORMED FOR EACH HOUR USING THE SPECI-PMT00450
C     FIED METEOROLOGICAL DATA. UP TO 24 DIFFERENT SETS OF HOURLY METEO-PMT00460
C     ROLOGICAL DATA MAY BE SPECIFIED AS INPUTS FOR THE DETERMINATION OFPMT00470
C     AIR QUALITY FOR 24 DISTINCT WEATHER SCENARIOS.  POLLUTANT CONCENT-PMT00480
C     RATIONS AND DEPOSITION FLUXES FOR A 2 TO 24 HOUR AVERAGING PERIOD PMT00490
C     ARE CALCULATED BY AVERAGING THE CORRESPONDING VALUES CALCULATED  PMT00500
C     FOR EACH HOUR IN THE PERIOD.                                     PMT00510
C                                                                      PMT00520
C        PEM IS BASED ON THE TEXAS EPISODIC MODEL (TEM, VERSION 8)     PMT00530
C     DEVELOPED BY THE TEXAS AIR CONTROL BOARD (1979).  TEM-8 USES THE PMT00540
C     GAUSSIAN PLUME CONCENTRATION ALGORITHMS DEVELOPED FOR NONREACTIVE PMT00550
C     POLLUTANTS AND A PERFECTLY REFLECTING SURFACE. CHEMICAL AND PHYSI-PMT00560
C     CAL DEPLETION PROCESSES ARE THEREFORE IGNORED EXCEPT FOR AN OPTIONPMT00570
C     WHICH ALLOWS A SIMPLE EXPONENTIAL DECAY OF POLLUTANT WITH TRAVEL PMT00580
C     TIME. THIS METHOD REQUIRES AN ACCURATE ESTIMATE OF THE POLLUTANT'SPMT00590
C     HALF-LIFE.                                                       PMT00600
C                                                                      PMT00610
C        IN CONTRAST, PEM EXPLICITLY ACCOUNTS FOR THE DRY DEPOSITION,  PMT00620
C     GRAVITATIONAL SETTLING, AND A FIRST-ORDER CHEMICAL TRANSFORMATION PMT00630
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```
C     OR DECAY OF GASEOUS OR PARTICULATE POLLUTANTS (OF ANY SIZE) IN    PMT00640
C     THE CONCENTRATION ALGORITHMS.  THESE ALGORITHMS, BASED ON EXACT   PMT00650
C     SOLUTIONS OF A GRADIENT-TRANSFER (K-THEORY) MODEL, WERE GIVEN BY  PMT00660
C     RAO (1981, 1982) AS ANALYTICAL EXTENSIONS OF THE WIDELY USED      PMT00670
C     GAUSSIAN PLUME DISPERSION ALGORITHMS UNDER VARIOUS ATMOSPHERIC    PMT00680
C     STABILITY AND MIXING CONDITIONS.  THUS, PEM TREATS DEPOSITION,    PMT00690
C     SEDIMENTATION, AND CHEMICAL TRANSFORMATION IN A PHYSICALLY REAL-  PMT00700
C     ISTIC AND STRAIGHTFORWARD MANNER, AND IT IS SUBJECT TO THE SAME   PMT00710
C     BASIC ASSUMPTIONS AND LIMITATIONS ASSOCIATED WITH ALL GAUSSIAN    PMT00720
C     PLUME-TYPE MODELS.  FOR FURTHER DETAILS REGARDING THE GRADIENT-   PMT00730
C     TRANSFER MODEL FORMULATIONS, ANALYTICAL SOLUTIONS, PARAMETERI-    PMT00740
C     ZATIONS, AND THE DEVELOPMENT OF THE ALGORITHMS FOR PEM, THE USER  PMT00750
C     SHOULD CONSULT THE REPORTS BY RAO (1981, 1982).  AN EVALUATION OF PMT00760
C     OF THE PEM USING THE ST.LOUIS/RAPS DATA FOR FIVE POLLUTANT SPECIESPMT00770
C     CAN BE FOUND IN THE REPORT BY PENDERGRASS AND RAO (1983).         PMT00780
C                                                                       PMT00790
C        THE PEM-2 MODEL (RAO, 1984) IS DEVELOPED FROM THE PEM (RAO AND PMT00800
C     STEVENS, 1982) WITH THE FOLLOWING KEY MODIFICATIONS:              PMT00810
C                                                                       PMT00820
C     (1) PEM-2 USES BRIGGS' URBAN DISPERSION PARAMETERS (BASED ON THE  PMT00830
C         ST. LOUIS DIFFUSION DATA OF MCELROY AND POOLER) FOR BOTH POINTPMT00840
C         AND AREA SOURCES, WHEREAS PEM USES THE SAME DISPERSION PARAME-PMT00850
C         AS THE TEM-8.                                                 PMT00860
C     (2) THE NUMBER OF STABILITY CLASSES IN PEM-2 ARE REDUCED TO SIX   PMT00870
C         (FROM SEVEN IN THE PEM).                                      PMT00880
C     (3) FOR BUOYANCY-DOMINATED PLUMES IN UNSTABLE/NEUTRAL ATMOSPHERE, PMT00890
C         BRIGGS' NEW PLUME RISE EQUATIONS AND PLUME PENETRATION (OF AN PMT00900
C         ELEVATED STABLE LAYER) SCHEMES ARE INCLUDED AS OPTIONAL FEATU-PMT00910
C         RES IN PEM-2.                                                 PMT00920
C     (4) AN OPTION IS PROVIDED TO USE SITE-SPECIFIC VALUES FOR THE     PMT00930
C         EXPONENTS OF THE WIND-PROFILE POWER LAW AND ANEMOMETER HEIGHT PMT00940
C         AS INPUTS TO PEM-2.                                           PMT00950
C     (5) CONCENTRATIONS FROM AREA SOURCES ARE COMPUTED BY NUMERICAL IN-PMT00960
C         TEGRATION IN PEM-2, WHILE THEY ARE CALCULATED FROM CONCENTRA- PMT00970
C         TION ALGORITHMS BASED ON MASS BUDGETS OF THE SPECIES IN PEM.  PMT00980
C         THE USER MAY SPECIFY AN EFFECTIVE HEIGHT OF EMISSIONS FOR     PMT00990
C         URBAN AREA SOURCES IN PEM-2, WHEREAS THESE EMISSIONS ARE      PMT01000
C         ASSUMED TO OCCUR ONLY AT GROUND-LEVEL IN PEM.                 PMT01010
C         THE NUMBER OF CALCULATION GRID SQUARES USED FOR EACH AREA     PMT01020
C         SOURCE HAVE BEEN INCREASED TO 9 (IN PEM-2) FROM 5 IN PEM TO   PMT01030
C         INCREASE THE PLUME LENGTH AND IMPROVE THE MODEL PERFORMANCE.  PMT01040
C                                                                       PMT01050
C        BASED ON THE NUMBER OF POLLUTANTS (NPOL=1 OR 2) AND THE CHEMI- PMT01060
C     CAL TRANSFORMATION/DECAY OPTION PARAMETER (ICT=0 OR 1) SPECIFIED  PMT01070
C     IN THE MODEL INPUT, PEM-2 PROGRAM DOES ONE OF THE FOLLOWING:      PMT01080
C                                                                       PMT01090
C     (1) IF NPOL=1 AND ICT=0 OR 1, SURFACE CONCENTRATIONS AND DEPOSI-  PMT01100
C         TION FLUXES OF ONE GASEOUS OR PARTICULATE POLLUTANT, WITH THE PMT01110
C         GIVEN DEPOSITION AND SETTLING VELOCITIES, VD1 AND W1 RESPECTI-PMT01120
C         VELY, ARE CALCULATED.  IF ICT=1, THEN CHEMICAL DECAY OF POLLU-PMT01130
C         TANT IS ALSO CONSIDERED IF THE DECAY RATE XKT > 0. IS GIVEN   PMT01140
C         IN PERCENT PER HOUR.                                          PMT01150
C                                                                       PMT01160
C     (2) IF NPOL=2 AND ICT=0, SURFACE CONCENTRATIONS AND DEPOSITION    PMT01170
C         FLUXES OF TWO DIFFERENT AND UNCOUPLED GASEOUS OR PARTICULATE  PMT01180
C         POLLUTANT SPECIES WITH THE GIVEN DEPOSITION AND SETTLING VELOC-PMT01190
C         ITIES VD1 AND W1 (FOR SPECIES-1) AND VD2 AND W2 (FOR SPECIES-2)PMT01200
C         RESPECTIVELY, ARE CALCULATED.  EMISSION RATES FOR BOTH SPECIES PMT01210
C         MAY BE DIFFERENT.  CHEMICAL DECAY IS NOT CONSIDERED FOR EITHER PMT01220
C         SPECIES EVEN IF A VALUE OF XKT > 0. IS SPECIFIED.             PMT01230
C                                                                       PMT01240
C     (3) IF NPOL=2 AND ICT=1, THE TWO GASEOUS OR PARTICULATE POLLUTANT PMT01250
C         SPECIES ARE COUPLED THROUGH A FIRST-ORDER CHEMICAL TRANSFORMA- PMT01260
C         TION.  THE SURFACE CONCENTRATIONS AND DEPOSITION FLUXES OF BOTHPMT01270
C         THE PRIMARY POLLUTANT (SPECIES-1 OR REACTANT) AS WELL AS THE  PMT01280
C         SECONDARY POLLUTANT (SPECIES-2 OR REACTION PRODUCT) ARE CALCU- PMT01290
C         LATED.  THE CHEMICAL TRANSFORMATION RATE (XKT > 0.) SHOULD BE PMT01300
C         GIVEN.  BOTH SPECIES MAY BE GIVEN NON-EQUAL DEPOSITION AND SET-PMT01310
C         TLING VELOCITIES.  A NON-ZERO DIRECT EMISSION RATE FOR THE    PMT01320
C         SECONDARY POLLUTANT FROM  THE POINT AND/OR AREA SOURCES MAY   PMT01330
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C        ALSO BE SPECIFIED AS INPUT FOR THIS CASE.                          PMT01340
C                                                                           PMT01350
C        FOR FURTHER DETAILS REGARDING THE MODIFICATION OF THE PEM TO       PMT01360
C     DEVELOP PEM-2, THE USE OF THE PEM-2 AND ITS I/O OPTIONS, INPUT        PMT01370
C     PARAMETERS AND UNITS, AND EXAMPLE PROBLEMS, THE USER SHOULD           PMT01380
C     CONSULT THE PEM-2 USER'S GUIDE BY RAO (1984).                         PMT01390
C                                                                           PMT01400
C                              *** REFERENCES ***                           PMT01410
C                                                                           PMT01420
C     (1) STAFF OF THE TEXAS AIR CONTROL BOARD, 1979:  USER'S GUIDE :       PMT01430
C         TEXAS EPISODIC MODEL.  TEXAS AIR CONTROL BOARD, PERMITS           PMT01440
C         SECTION, AUSTIN, TEXAS 78723, 215 PP.                             PMT01450
C                                                                           PMT01460
C     (2) PENDERGRASS, W. R., AND K. S. RAO, 1983:  EVALUATION OF THE       PMT01470
C         POLLUTION EPISODIC MODEL USING THE RAPS DATA.                     PMT01480
C         EPA-600/3-84-087, U.S.E.P.A., RESEARCH TRIANGLE PARK, NC;         PMT01490
C         NOAA TECH. MEMO. ERL ARL-128, NOAA-ATDL, OAK RIDGE, TN 37831,     PMT01500
C         47 PP.  ATDL CONTRIBUTION FILE 83/18.                             PMT01510
C                                                                           PMT01520
C     (3) RAO, K. S., 1981:  ANALYTICAL SOLUTIONS OF A GRADIENT-TRANSFERPMT01530
C         MODEL FOR PLUME DEPOSITION AND SEDIMENTATION.                     PMT01540
C         EPA-600/3-82-079, U.S.E.P.A., RESEARCH TRIANGLE PARK, NC;         PMT01550
C         NOAA TECH. MEMO. ERL ARL-109, NOAA-ATDL, OAK RIDGE, TN 37831,     PMT01560
C         75 PP.  ATDL CONTRIBUTION FILE NO. 81/14.                         PMT01570
C                                                                           PMT01580
C     (4) RAO, K. S., 1982:  PLUME CONCENTRATION ALGORITHMS WITH            PMT01590
C         DEPOSITION, SEDIMENTATION, AND CHEMICAL TRANSFORMATION.           PMT01600
C         EPA-600/3-84-042, U.S.E.P.A., RESEARCH TRIANGLE PARK, NC;         PMT01610
C         NOAA TECH. MEMO. ERL ARL-124, NOAA-ATDL, OAK RIDGE, TN 37831,     PMT01620
C         87 PP.  ATDL CONTRIBUTION FILE NO. 82/27.                         PMT01630
C                                                                           PMT01640
C     (5) RAO, K. S., AND M. M. STEVENS, 1982:  POLLUTION EPISODIC          PMT01650
C         MODEL USER'S GUIDE.                                               PMT01660
C         EPA-600/8-84-008, U.S.E.P.A., RESEARCH TRIANGLE PARK, NC;         PMT01670
C         NOAA TECH. MEMO. ERL ARL-125, NOAA-ATDL, OAK RIDGE, TN 37831,     PMT01680
C         186 PP.  ATDL CONTRIBUTION FILE NO. 82/28.                        PMT01690
C                                                                           PMT01700
C     (6) RAO, K. S., 1984:  PEM-2 : POLLUTION EPISODIC MODEL               PMT01710
C         (VERSION 2) USER'S GUIDE.                                         PMT01720
C         EPA-            , U.S.E.P.A., RESEARCH TRIANGLE PARK, NC;         PMT01730
C         NOAA TECH. MEMO. ERL ARL-    , NOAA-ATDL, OAK RIDGE, TN 37831,    PMT01740
C         ATDL CONTRIBUTION FILE NO. 84/1 .                                 PMT01750
C                                                                           PMT01760
C                                                                           PMT01770
C     QUESTIONS OR COMMENTS MAY BE REFERRED TO:
C
C         JAMES M. GODOWITCH
C         ATMOSOSPHERIC MODELING BRANCH - M.D. 80
C         U.S. ENVIRONMENTAL PROTECTION AGENCY
C         RESEARCH TRIANGLE PARK, NC 27711
C
C         PHONE: (919) 541-4802
C                FTS: 629-4802
C
C
C *** PEM-2 (VERSION 84130) : FORTRAN LISTING.                              PMT01780
C                                                                           PMT01790
C                                                                           PMT01800
C                                                                           PMT01810
C                                                                           PMT01820
C                                                                           PMT01830
C *** COMMON BLOCKS, DIMENSIONS, AND DATA STATEMENTS.                       PMT01840
C                                                                           PMT01850
C                                                                           PMT01860
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                      PMT01870
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),           PMT01880
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                     PMT01890
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                             PMT01900
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),                  PMT01910
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),              PMT01920
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     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,                PMT01930
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                   PMT01940
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,                PMT01950
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,      PMT01960
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT01970
C                                                                       PMT01980
      COMMON/PARM1/NPOL,VD1,W1,VD2,W2                                   PMT01990
      COMMON/PARM1A/ICT,TAUC,GAMMA                                      PMT02000
      COMMON/PARM2/ISPEC,UTAUC,Q2Q1,XCT,EXCT                            PMT02010
      COMMON/PARM2A/HAS,KSC,AA,BA,CA                                    PMT02020
      COMMON/PARM3/HC,VDC1,WC1,VDC2,WC2                                 PMT02030
      COMMON/PARM4/V11,V21,V12,V22,V13                                  PMT02040
      COMMON/PARM5/D11,D21,D12,D22,D31,D32,D33,D6                       PMT02050
      COMMON/PARM6/R11,R21,R12,R22,R13,R23,R31,R41,R32,R42              PMT02060
      COMMON/PARM7/QZC1,QZC2,HGT                                        PMT02070
      COMMON/PARM7A/HA,P1(6)                                            PMT02080
      COMMON/BLOCK1/PI,SQPI,SQRT2,A1B,A1C                               PMT02090
      COMMON/BLOCK2/AI,BI,EPSABS,EPSREL,LW,NIW                          PMT02100
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX                                PMT02110
      COMMON/WND/HMIN,HMAX,UMIN,IUFLG                                   PMT02111
C                                                                       PMT02120
      EXTERNAL FUN3,FUN4,FUN5                                           PMT02130
      REAL*8 FUN3,FUN4,FUN5,X1A,X2A                                     PMT02140
      REAL*8 AI,BI,EPSABS,EPSREL,RESULT                                 PMT02150
C     DIMENSION IW(102)                                                 PMT02160
      DIMENSION PRL(2,2),DWL(4),ANGLIM(6)                               PMT02170
      DIMENSION ITABLE(9,10),EPSLIM(10),AY(6)                           PMT02180
      DIMENSION XA1(9),XA2(9),RCA1(9),RCA2(9),AUX(25)                   PMT02190
      DIMENSION RCA2CH(9),RCA2CT(9,50),QA2QA1(50)                       PMT02200
C                                                                       PMT02210
      DATA PRL/4HMOME,4HNTUM,4HBUOY,4HANCY/                             PMT02220
      DATA DWL/4H    ,4H    ,4HDOWN,4HWASH/                             PMT02230
      DATA EPSLIM/.12427,.16511,.24504,.35884,.46373,                   PMT02240
     1            .55868,.64350,.69482,.71890,.78540/                   PMT02250
      DATA ITABLE/0,0,0,0,0,0,0,0,0, 0,0,0,0,1,1,1,1,1,                 PMT02260
     1            0,0,0,1,1,1,1,1,2, 0,0,1,1,1,2,2,2,2,                 PMT02270
     2            0,0,1,1,2,2,3,3,3, 0,1,1,2,2,3,3,4,4,                 PMT02280
     3            0,1,1,2,3,3,4,5,5, 0,1,2,2,3,4,5,6,6,                 PMT02290
     4            0,1,2,3,3,4,5,6,7, 0,1,2,3,4,5,6,7,8/                 PMT02300
      DATA ANGLIM/0.750492,0.750492,0.575959,0.436332,                  PMT02310
     1 0.314159,0.314159/                                               PMT02320
      DATA AY/.32,.32,.22,.16,.11,.11/                                  PMT02330
C                                                                       PMT02340
C                                                                       PMT02350
      CALL WSTCLK
C                                                                       PMT02360
C *** DEFINE PROGRAM CONSTANTS.                                         PMT02370
C                                                                       PMT02380
      PI=3.1415927                                                      PMT02390
      PI2=PI/2.                                                         PMT02400
      SQPI=SQRT(PI)                                                     PMT02410
      SQRT2=SQRT(2.)                                                    PMT02420
      A1B=1000./(SQRT2*SQPI)                                            PMT02430
      A1C=2.*SQPI                                                       PMT02440
      A1D=SQRT2/SQPI                                                    PMT02450
      AI=0.                                                             PMT02460
      BI=1.                                                             PMT02470
      EPSABS=1.0E-3                                                     PMT02480
      EPSREL=1.0E-3                                                     PMT02490
      LW=800                                                            PMT02500
      NIW=102                                                           PMT02510
C     FOR IBM-3033                                                      PMT02520
C     EXPMAX=174.                                                       PMT02530
C     FOR UNIVAC-1100                                                   PMT02540
      EXPMAX=87.                                                        PMT02550
      EXPMIN=50.                                                        PMT02560
      ETAMAX=SQRT(EXPMAX)                                               PMT02570
C                                                                       PMT02580
      WRITE(IWR,5430)
 5430 FORMAT ('1',21X,'PEM-2.0   (DATED 86016)',/,22X,
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     1 'AN AIR QUALITY DISPERSION MODEL IN',/,22X,'SECTION 2. ',
     2 'NON-GUIDELINE MODELS',/,22X,'IN UNAMAP (VERSION 6) ',
     3 'JULY 86.',/,22X,'SOURCE:  UNAMAP FILE ON EPA''S ',
     4 'UNIVAC AT RTP, NC.')
C
      WRITE (IWR,5432)
 5432 FORMAT (///////45X,'PEM-2   (VERSION  84130)'/////
     1 45X,'POLLUTION EPISODIC MODEL'/////
     2 52X,'INCLUDING'//
     3 30X,'DEPOSITION, SEDIMENTATION, AND CHEMICAL TRANSFORMATION'//
     4 50X,'OF POLLUTANTS'/)
C
      INDEX=0
C
C  CALL MODEL INPUT ROUTINE TO READ ALL CONTROL PARAMETERS, GRID
C     INFORMATION, METEOROLOGICAL AND EMISSION DATA, AND POLLUTANT
C     DEPOSITION AND TRANSFORMATION PARAMETERS.
C
C     ************
      CALL INMOD
C     ************
C
      VD136=VD1*36.
      VD236=VD2*36.
C
C
C *** DETERMINE VALUE OF PARAMETER ISPEC.
C     ISPEC IS AN INTERNAL ROUTING PARAMETER USED IN PEM-2
C     TO DETERMINE THE APPROPRIATE CONCENTRATION ALGORITHMS
C     TO BE USED FOR A GIVEN PROBLEM.
C     VALUE OF ISPEC  IS BASED ON NUMBER OF POLLUTANTS,
C     AND CHEMICAL TRANSFORMATION OPTION PARAMETER.
C
      IF(NPOL.EQ.2) GO TO 41
C     ONLY ONE POLLUTANT SPECIES.  FIRST-ORDER CHEMICAL DECAY CAN BE
C     CONSIDERED BY SPECIFYING ICT = 1 AND XKT > 0.
      ISPEC=1
      GO TO 43
C
C     TWO POLLUTANT SPECIES.
   41 IF(ICT.EQ.1) GO TO 42
C     NO CHEMICAL COUPLING. THE TWO SPECIES ARE INDEPENDENT
C     OF EACH OTHER.  CHEMICAL DECAY IS NOT CONSIDERED FOR
C     EITHER SPECIES.
      ISPEC=2
      GO TO 43
C
C     CHEMICAL COUPLING EXISTS BETWEEN SPECIES-1 (REACTANT)
C     AND SPECIES-2 (PRODUCT). FIRST-ORDER TRANSFORMATION.
   42 ISPEC=3
   43 CONTINUE
C
C
C
C *** DEFINE TIME-AVERAGING MULTIPLIER CONSTANTS.
C
      IF(NTOPT.EQ.1) STCONV = 1.
      IF(NTOPT.EQ.2) STCONV= 0.04166667
      IF(NTOPT.EQ.3) STCONV= 1.0/FLOAT(NSCEN)
C
      INDEX=1
C
C  CALL INPUT ROUTINE TO BRING IN METEOROLOGICAL DATA FOR ONE SCENARIO
C    (NUMBER OF SCENARIO = ISCEN).
C
C     ************
100   CALL INMOD
C     ************
C
C  CALCULATE WIND VECTOR (WVEC) FOR SCENARIO. IFLAG IS USED BELOW
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C     (STMT. 275) TO DETERMINE METHOD OF RESTRICTING THE AREA OF THE      PMT03240
C     RECEPTOR GRID AFFECTED BY EACH SOURCE.                              PMT03250
C                                                                         PMT03260
175    IF(NWDOPT.EQ.1) GO TO 200                                          PMT03270
       DO 180 IWD=1,16                                                    PMT03280
       DETA=ABS(WD(ISCEN)-SECTAN(IWD))                                    PMT03290
       IF(DETA.LE.0.19634954) GO TO 205                                   PMT03300
180    CONTINUE                                                           PMT03310
       GO TO 205                                                          PMT03320
200    WD(ISCEN)=SECTAN(IWD)                                              PMT03330
205    IF(IWD.LT.8.OR.IWD.GT.10) GO TO 210                                PMT03340
       IFLAG=1                                                            PMT03350
       GO TO 241                                                          PMT03360
210    IF(IWD.NE.11) GO TO 215                                            PMT03370
       IFLAG=2                                                            PMT03380
       GO TO 241                                                          PMT03390
215    IF(IWD.LT.12.OR.IWD.GT.14) GO TO 220                               PMT03400
       IFLAG=3                                                            PMT03410
       GO TO 241                                                          PMT03420
220    IF(IWD.NE.15) GO TO 225                                            PMT03430
       IFLAG=4                                                            PMT03440
       GO TO 241                                                          PMT03450
225    IF(IWD.LT.16.AND.IWD.GT.2) GO TO 230                               PMT03460
       IFLAG=5                                                            PMT03470
       GO TO 241                                                          PMT03480
230    IF(IWD.NE.3) GO TO 235                                             PMT03490
       IFLAG=6                                                            PMT03500
       GO TO 241                                                          PMT03510
235    IF(IWD.LT.4.OR.IWD.GT.6) GO TO 240                                 PMT03520
       IFLAG=7                                                            PMT03530
       GO TO 241                                                          PMT03540
240    IFLAG=8                                                            PMT03550
241    WVEC= WD(ISCEN) + 3.14159265                                       PMT03560
       IF(WVEC.GT.6.2831853) WVEC=WVEC - 6.2831853                        PMT03570
       WDV=4.712388981-WD(ISCEN)                                          PMT03580
       IF(WDV.LT.0.)WDV=WDV+6.283185307                                   PMT03590
       WDPANG=WDV+ANGLIM(ISC)                                             PMT03600
       WDMANG=WDV-ANGLIM(ISC)                                             PMT03610
C                                                                         PMT03620
       AA=AZ(ISC)                                                         PMT03630
       BA=BZ(ISC)                                                         PMT03640
       CA=CZ(ISC)                                                         PMT03650
       KSC=ISC                                                            PMT03660
C                                                                         PMT03670
C                                                                         PMT03680
C  CALL AUTGRD TO CALCULATE RECEPTOR GRID PARAMETERS AUTOMATICALLY.       PMT03690
C      ************                                                       PMT03700
       IF(IGRID.EQ.1) CALL AUTGRD                                         PMT03710
C      ************                                                       PMT03720
C                                                                         PMT03730
C *** INITIALIZATION.                                                     PMT03740
C                                                                         PMT03750
C  INITIALIZE CONCENTRATION AND SURFACE DEPOSITION FLUX ARRAYS            PMT03760
       IF(NTOPT.GT.1.AND.ISCEN.GT.1) GO TO 4                              PMT03770
       DO 2 I=1,LX                                                        PMT03780
       DO 2 J=1,LY                                                        PMT03790
       CONC(I,J,1)=0.                                                     PMT03800
       SDF(I,J,1)=0.                                                      PMT03810
       IF(ISPEC.EQ.1.AND.NCSOPT.EQ.0) GO TO 2                             PMT03820
       CONC(I,J,2)=0.                                                     PMT03830
       SDF(I,J,2)=0.                                                      PMT03840
     2 CONTINUE                                                           PMT03850
C                                                                         PMT03860
C                                                                         PMT03870
C                                                                         PMT03880
     4 VGRID= 1./GRID                                                     PMT03890
       GRIDSQ= GRID*GRID                                                  PMT03900
       ELX= LX                                                            PMT03910
       ELY= LY                                                            PMT03920
       XB1= XSWC + 0.5*GRID                                               PMT03930
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      XB2= XSWC + (ELX-0.5)*GRID                                        PMT03940
      YB1= YSWC + 0.5*GRID                                              PMT03950
      YB2= YSWC + (ELY-0.5)*GRID                                        PMT03960
C                                                                       PMT03970
C                                                                       PMT03980
C***  A R E A   S O U R C E   C A L C U L A T I O N S  ***              PMT03990
C                                                                       PMT04000
C     IF NO AREA SOURCES, SKIP AREA SOURCE CALCULATIONS.                PMT04010
      IF(NAS.LT.1) GO TO 245                                            PMT04020
C                                                                       PMT04030
C     IWV HELPS DETERMINE THE PATTERN OF GRID SQUARES AFFECTED BY EACH  PMT04040
C     AREA SOURCE.  PATTERN DEPENDS ONLY ON WIND DIRECTION.             PMT04050
C     EPS IS THE ANGLE BETWEEN THE WIND VECTOR AND THE NEAREST          PMT04060
C     COORDINATE AXIS.                                                  PMT04070
C                                                                       PMT04080
      IWV= 1 + WVEC/0.78540                                             PMT04090
      GO TO (2411,2412,2413,2414,2415,2416,2417,2418),IWV               PMT04100
2411  ITABX=1                                                           PMT04110
      ISIGNX=1                                                          PMT04120
      ISIGNY=1                                                          PMT04130
      EPS= WVEC                                                         PMT04140
      GO TO 2419                                                        PMT04150
2412  ITABX=0                                                           PMT04160
      ISIGNX=1                                                          PMT04170
      ISIGNY=1                                                          PMT04180
      EPS= 1.5708 - WVEC                                                PMT04190
      GO TO 2419                                                        PMT04200
2413  ITABX=0                                                           PMT04210
      ISIGNX=1                                                          PMT04220
      ISIGNY=-1                                                         PMT04230
      EPS= WVEC - 1.57080                                               PMT04240
      GO TO 2419                                                        PMT04250
2414  ITABX=1                                                           PMT04260
      ISIGNX=1                                                          PMT04270
      ISIGNY=-1                                                         PMT04280
      EPS= 3.1416 - WVEC                                                PMT04290
      GO TO 2419                                                        PMT04300
2415  ITABX=1                                                           PMT04310
      ISIGNX=-1                                                         PMT04320
      ISIGNY=-1                                                         PMT04330
      EPS= WVEC - 3.1416                                                PMT04340
      GO TO 2419                                                        PMT04350
2416  ITABX=0                                                           PMT04360
      ISIGNX=-1                                                         PMT04370
      ISIGNY=-1                                                         PMT04380
      EPS= 4.7124 - WVEC                                                PMT04390
      GO TO 2419                                                        PMT04400
2417  ITABX=0                                                           PMT04410
      ISIGNX=-1                                                         PMT04420
      ISIGNY=1                                                          PMT04430
      EPS= WVEC - 4.7124                                                PMT04440
      GO TO 2419                                                        PMT04450
2418  ITABX=1                                                           PMT04460
      ISIGNX=-1                                                         PMT04470
      ISIGNY=1                                                          PMT04480
      EPS= 6.2832 - WVEC                                                PMT04490
2419  IF(ITABX.EQ.0) GO TO 2420                                         PMT04500
      ITABY=0                                                           PMT04510
      INCRX=0                                                           PMT04520
      INCRY=1                                                           PMT04530
      GO TO 2421                                                        PMT04540
2420  ITABY=1                                                           PMT04550
      INCRX=1                                                           PMT04560
      INCRY=0                                                           PMT04570
2421  DO 2422 L=1,10                                                    PMT04580
      IF(EPS.GT.EPSLIM(L)) GO TO 2422                                   PMT04590
      IEPS=L                                                            PMT04600
      GO TO 2423                                                        PMT04610
2422  CONTINUE                                                          PMT04620
      IEPS=10                                                           PMT04630
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C                                                                       PMT04640
 2423 DXA=1000.*GRID/COS(EPS)                                           PMT04650
      IF(NWPOPT.EQ.1) THEN                                              PMT04660
C   OPTIONAL WIND PROFILE EXPONENTS USED                                PMT04670
      CALL WIND(WS(ISCEN),P1(ISC),HAS,UPL)                              PMT04680
      ELSE                                                              PMT04690
C    DEFAULT URBAN WIND PROFILE EXPONENTS USED                          PMT04700
      CALL WIND(WS(ISCEN),P(ISC),HAS,UPL)                               PMT04710
      END IF                                                            PMT04720
      UINV=1./UPL                                                       PMT04730
      UPL=1./UINV                                                       PMT04740
      UINV1=UINV/100.                                                   PMT04750
C                                                                       PMT04760
C     DEFINE NONDIMENSIONAL DEPOSITION AND SEDIMENTATION PARAMETERS.    PMT04770
C                                                                       PMT04780
C     ISPEC = 1 OR 2 OR 3                                               PMT04790
      VDC1=VD1*UINV1                                                    PMT04800
      WC1=W1*UINV1                                                      PMT04810
      V11=VDC1-0.5*WC1                                                  PMT04820
      V21=VDC1-WC1                                                      PMT04830
      IF(ISPEC.EQ.1) GO TO 46                                           PMT04840
C                                                                       PMT04850
C     ISPEC = 2 OR 3                                                    PMT04860
      VDC2=VD2*UINV1                                                    PMT04870
      WC2=W2*UINV1                                                      PMT04880
      V12=VDC2-0.5*WC2                                                  PMT04890
      V22=VDC2-WC2                                                      PMT04900
      IF(ISPEC.EQ.2) GO TO 47                                           PMT04910
C                                                                       PMT04920
C     ISPEC = 3                                                         PMT04930
      V13=V11-0.5*(WC1-WC2)                                             PMT04940
C                                                                       PMT04950
C     ISPEC = 1 OR 3                                                    PMT04960
   46 UTAUC=TAUC*UPL                                                    PMT04970
   47 CONTINUE                                                          PMT04980
C                                                                       PMT04990
C                                                                       PMT05000
C     CALCULATE RELATIVE CONCENTRATIONS AT A RECEPTOR LOCATED AT THE    PMT05010
C     CENTER OF THE CALCULATION GRID SQUARE CONTAINING THE AREA SOURCE  PMT05020
C     EMISSIONS, AND AT THE CENTER OF EACH OF THE EIGHT GRID SQUARES    PMT05030
C     IMMEDIATELY DOWNWIND OF THE SOURCE.                               PMT05040
C                                                                       PMT05050
      NDIM=15                                                           PMT05060
      EPSAXI=.01                                                        PMT05070
      XA1(1)=1.0                                                        PMT05080
      XA2(1)=0.5*DXA                                                    PMT05090
C                                                                       PMT05100
C     START LOOP ON NINE CALCULATION GRID SQUARES WITH RECEPTORS        PMT05110
      DO 111 I=1,9                                                      PMT05120
      X1A=XA1(I)                                                        PMT05130
      X2A=XA2(I)                                                        PMT05140
C                                                                       PMT05150
C     SPECIES-1 CONCENTRATION  (ISPEC = 1 OR 2 OR 3)                    PMT05160
C     COMPUTE INTEGRAL F3(X1A,X2A); FUN3 IS THE EXTERNALLY              PMT05170
C     DEFINED INTEGRAND FUNCTION.                                       PMT05180
C     ************                                                      PMT05190
      CALL XINTEG(X1A,X2A,EPSAXI,NDIM,FUN3,RESULT,IER1,AUX)             PMT05200
C     ************                                                      PMT05210
      RCA1(I)=A1D*RESULT                                                PMT05220
      IF(ISPEC.EQ.1) GO TO 108                                          PMT05230
C                                                                       PMT05240
C     SPECIES-2 CONCENTRATION                                           PMT05250
C     ISPEC=2 OR ISPEC=3 (DIRECT EMISSION CONTRIBUTION)                 PMT05260
C     COMPUTE INTEGRAL F5(X1A,X2A); FUN5 IS THE EXTERNALLY              PMT05270
C     DEFINED INTEGRAND FUNCTION.                                       PMT05280
C     ************                                                      PMT05290
      CALL XINTEG(X1A,X2A,EPSAXI,NDIM,FUN5,RESULT,IER2,AUX)             PMT05300
C     ************                                                      PMT05310
      RCA2(I)=A1D*RESULT                                                PMT05320
      IF(ISPEC.EQ.2) GO TO 108                                          PMT05330
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C                                                                       PMT05340
C     SPECIES-2 CONCENTRATION                                           PMT05350
C     ISPEC=3 (CHEMICAL TRANSFORMATION CONTRIBUTION)                    PMT05360
C     COMPUTE INTEGRAL F4(X1A,X2A); FUN4 IS THE EXTERNALLY              PMT05370
C     DEFINED INTEGRAND FUNCTION.                                       PMT05380
C     ************                                                      PMT05390
      CALL XINTEG(X1A,X2A,EPSAXI,NDIM,FUN4,RESULT,IER3,AUX)             PMT05400
C     ************                                                      PMT05410
      RCA2CH(I)=A1D*GAMMA*RESULT                                        PMT05420
C                                                                       PMT05430
  108 IF(I.EQ.9) GO TO 111                                              PMT05440
      XA1(I+1)=XA2(I)                                                   PMT05450
      XA2(I+1)=XA1(I+1)+DXA                                             PMT05460
  111 CONTINUE                                                          PMT05470
C     END LOOP ON I=1,9 CALCULATION GRID SQUARES.                       PMT05480
C                                                                       PMT05490
      IF(ISPEC.NE.3) GO TO 114                                          PMT05500
C     START LOOP ON ALL AREA SOURCES IF ISPEC=3                         PMT05510
      DO 114 K=1,NAS                                                    PMT05520
      IF(EA(K,1).LT.1.E-6) EA(K,1)=1.E-6                                PMT05530
      QA2QA1(K)=EA(K,2)/EA(K,1)                                         PMT05540
      DO 113 I=1,9                                                      PMT05550
      RCA2CT(I,K)=QA2QA1(K)*RCA2(I) + RCA2CH(I)                         PMT05560
  113 CONTINUE                                                          PMT05570
  114 CONTINUE                                                          PMT05580
C     END LOOP ON K=1,NAS AREA SOURCES IF ISPEC = 3                     PMT05590
C                                                                       PMT05600
C                                                                       PMT05610
C  LOOP THROUGH ALL AREA SOURCES.  EMISSIONS FROM EACH AREA SOURCE      PMT05620
C    ARE APPORTIONED AMONG THE RECEPTOR GRID SQUARES WHOLLY OR          PMT05630
C    PARTIALLY COVERED BY THE SOURCE.  EACH AFFECTED RECEPTOR GRID      PMT05640
C    SQUARE IS TREATED AS A SOURCE.                                     PMT05650
C                                                                       PMT05660
C     START LOOP ON K=1,NAS AREA SOURCES.                               PMT05670
      DO 2429 K=1,NAS                                                   PMT05680
      AREA= SIZE(K)*SIZE(K)                                             PMT05690
      AX1= XA(K)                                                        PMT05700
      AX2= AX1 + SIZE(K)                                                PMT05710
      NX1= (AX1-XSWC)*VGRID + 9.                                        PMT05720
      NX2= (AX2-XSWC)*VGRID + 9.                                        PMT05730
      IF(NX1.GT.LX+16.OR.NX2.LT.1) GO TO 2429                           PMT05740
      IF(NX1.GE.1) GO TO 32                                             PMT05750
      NX1= 1                                                            PMT05760
      AX1= XSWC - 8.*GRID                                               PMT05770
32    IF(NX2.LE.LX+16) GO TO 34                                         PMT05780
      NX2= LX+16                                                        PMT05790
      AX2= XSWC + (ELX + 8.)*GRID                                       PMT05800
34    X1= XSWC + (FLOAT(NX1)-9.)*GRID                                   PMT05810
      X2= XSWC + (FLOAT(NX2)-8.)*GRID                                   PMT05820
      AY1= YA(K)                                                        PMT05830
      AY2= AY1 + SIZE(K)                                                PMT05840
      NY1= (AY1-YSWC)*VGRID + 9.                                        PMT05850
      NY2= (AY2-YSWC)*VGRID + 9.                                        PMT05860
      IF(NY1.GT.LY+16.OR.NY2.LT.1) GO TO 2429                           PMT05870
      IF(NY1.GE.1) GO TO 36                                             PMT05880
      NY1= 1                                                            PMT05890
      AY1= YSWC - 8.*GRID                                               PMT05900
36    IF(NY2.LE.LY+16) GO TO 38                                         PMT05910
      NY2= LY+16                                                        PMT05920
      AY2= YSWC + (ELY + 8.)*GRID                                       PMT05930
38    Y1= YSWC + (FLOAT(NY1)-9.)*GRID                                   PMT05940
      Y2= YSWC + (FLOAT(NY2)-8.)*GRID                                   PMT05950
C                                                                       PMT05960
C     START LOOP ON IX=NX1,NX2 COLUMNS OF THE RECEPTOR GRID.            PMT05970
      DO 2428 IX=NX1,NX2                                                PMT05980
      IF(NX1.NE.NX2) GO TO 10                                           PMT05990
      DXQ= AX2-AX1                                                      PMT06000
      GO TO 13                                                          PMT06010
10    IF(IX.NE.NX1) GO TO 11                                            PMT06020
      DXQ= GRID+X1-AX1                                                  PMT06030
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      GO TO 13                                                          PMT06040
11    IF(IX.NE.NX2) GO TO 12                                            PMT06050
      DXQ= GRID+AX2-X2                                                  PMT06060
      GO TO 13                                                          PMT06070
12    DXQ=GRID                                                          PMT06080
C                                                                       PMT06090
C     START LOOP ON JY=NY1,NY2 ROWS OF THE RECEPTOR GRID.               PMT06100
13    DO 2427 JY=NY1,NY2                                                PMT06110
      IF(NY1.NE.NY2) GO TO 20                                           PMT06120
      DY= AY2-AY1                                                       PMT06130
      GO TO 23                                                          PMT06140
20    IF(JY.NE.NY1) GO TO 21                                            PMT06150
      DY= GRID+Y1-AY1                                                   PMT06160
      GO TO 23                                                          PMT06170
21    IF(JY.NE.NY2) GO TO 22                                            PMT06180
      DY= GRID+AY2-Y2                                                   PMT06190
      GO TO 23                                                          PMT06200
22    DY=GRID                                                           PMT06210
23    SPLIT= DXQ*DY/(AREA*GRIDSQ)                                       PMT06220
C                                                                       PMT06230
C  LOOP FOR THE NINE RECEPTORS AFFECTED BY EACH RECEPTOR GRID SQUARE    PMT06240
C    CONTAINING EMISSIONS.  THE RECEPTORS IN THE EIGHT DOWNWIND SQUARES PMT06250
C    AND IN THE SOURCE SQUARE ITSELF ARE AFFECTED.                      PMT06260
C                                                                       PMT06270
      DO 2426 L=1,9                                                     PMT06280
      NX= IX + ISIGNX*(ITABLE(L,IEPS)*ITABX + (L-1)*INCRX) - 8          PMT06290
      IF(NX.LT.1.OR.NX.GT.LX) GO TO 2426                                PMT06300
      NY= JY + ISIGNY*(ITABLE(L,IEPS)*ITABY + (L-1)*INCRY) - 8          PMT06310
      IF(NY.LT.1.OR.NY.GT.LY) GO TO 2426                                PMT06320
C                                                                       PMT06330
C     CALCULATE GROUND-LEVEL CONCENTRATIONS CONC (MICROGRAMS PER CUBIC  PMT06340
C     METER) AND SURFACE DEPOSITION FLUXES SDF (MICROGRAMS PER SQUARE   PMT06350
C     METER PER HOUR) OF POLLUTANTS AT RECEPTOR IN COLUMN NX, ROW NY    PMT06360
C     OF THE RECEPTOR GRID DUE TO AREA SOURCE K.                        PMT06370
C                                                                       PMT06380
C     ISPEC = 1 OR 2 OR 3                                               PMT06390
      CINC1=RCA1(L)*EA(K,1)*SPLIT*STCONV*UINV                           PMT06400
      CONC(NX,NY,1)=CONC(NX,NY,1)+CINC1                                 PMT06410
      SDF(NX,NY,1)=SDF(NX,NY,1)+VD136*CINC1                             PMT06420
      IF(ISPEC.EQ.1) GO TO 2426                                         PMT06430
      IF(ISPEC.EQ.3) GO TO 2425                                         PMT06440
C                                                                       PMT06450
C     ISPEC = 2                                                         PMT06460
      CINC2=RCA2(L)*EA(K,2)*SPLIT*STCONV*UINV                           PMT06470
      CONC(NX,NY,2)=CONC(NX,NY,2)+CINC2                                 PMT06480
      SDF(NX,NY,2)=SDF(NX,NY,2)+VD236*CINC2                             PMT06490
      GO TO 2426                                                        PMT06500
C                                                                       PMT06510
C     ISPEC = 3                                                         PMT06520
 2425 CINC2=RCA2CT(L,K)*EA(K,1)*SPLIT*STCONV*UINV                       PMT06530
      CONC(NX,NY,2)=CONC(NX,NY,2)+CINC2                                 PMT06540
      SDF(NX,NY,2)=SDF(NX,NY,2)+VD236*CINC2                             PMT06550
C                                                                       PMT06560
2426  CONTINUE                                                          PMT06570
C     END LOOP ON L=1,9 CALCULATION GRID SQUARES WITH RECEPTORS.        PMT06580
C                                                                       PMT06590
2427  CONTINUE                                                          PMT06600
C     END LOOP ON JY=NY1,NY2 ROWS OF THE RECEPTOR GRID.                 PMT06610
C                                                                       PMT06620
2428  CONTINUE                                                          PMT06630
C     END LOOP ON IX=NX1,NX2 COLUMNS OF THE RECEPTOR GRID.              PMT06640
C                                                                       PMT06650
2429  CONTINUE                                                          PMT06660
C     END LOOP ON K=1,NAS AREA SOURCES.                                 PMT06670
C                                                                       PMT06680
C                                                                       PMT06690
C                                                                       PMT06700
C *** POINT SOURCES.                                                    PMT06710
C                                                                       PMT06720
C                                                                       PMT06730
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C  IF NO POINT SOURCES, SKIP POINT SOURCE CALCULATIONS.                  PMT06740
  245 IF(NPS.LT.1) GO TO 603                                             PMT06750
C                                                                        PMT06760
C                                                                        PMT06770
C                                                                        PMT06780
C***  P O I N T   S O U R C E   C A L C U L A T I O N S  ***             PMT06790
C                                                                        PMT06800
C  LOOP THROUGH ALL POINT SOURCES.                                       PMT06810
      DO 600 I=1,NPS                                                     PMT06820
      IF((NWDOPT.GT.1.AND.IWDOPT.GT.1).OR.NTOPT.EQ.2) GO TO 247          PMT06830
      IF(NPRINT.EQ.0) GO TO 247                                          PMT06840
      IF((I-1)/50*50.NE.I-1) GO TO 247                                   PMT06850
      IF(NINPEN.EQ.0) GO TO 246                                          PMT06860
      IF(ISC.GE.5) GO TO 246                                             PMT06870
      WRITE(IWR,1001) TT,ISCEN,HMIX(ISCEN),DTDZI(ISCEN)                  PMT06880
      WRITE(IWR,1003)                                                    PMT06890
      GO TO 247                                                          PMT06900
  246 WRITE(IWR,1005) TT,ISCEN,HMIX(ISCEN)                               PMT06910
      WRITE(IWR,1007)                                                    PMT06920
  247 IPS=I                                                              PMT06930
C     IF PHYSICAL STACK HEIGHT EXCEEDS MIXING HEIGHT, THE SOURCE         PMT06940
C     IS IGNORED.                                                        PMT06950
      IF(HP(I).GE.HMIX(ISCEN)) GO TO 600                                 PMT06960
      EFF= 2.45*VP(I)*DP(I)*DP(I)*(TP(I)-TA(ISCEN))/TP(I)                PMT06970
      IF(EFF.LT.0.) EFF=1.0E-7                                           PMT06980
C                                                                        PMT06990
C  CALCULATE INVERSE WIND SPEED (UINV) AT THE PHYSICAL HEIGHT (HP(I))    PMT07000
C    OF POINT SOURCE I.  DO NOT CHANGE IF STACK HEIGHT IS LESS           PMT07010
C    THAN 10 METERS.                                                     PMT07020
C                                                                        PMT07030
       IF(NWPOPT.EQ.1) THEN                                              PMT07040
C    USE OPTIONAL POWER LAW EXPONENTS                                    PMT07050
      CALL WIND(WS(ISCEN),P1(ISC),HP(I),UPL)                             PMT07060
      ELSE                                                               PMT07070
C    USE DEFAULT URBAN WIND PROFILE EXPONENTS                            PMT07080
      CALL WIND(WS(ISCEN),P(ISC),HP(I),UPL)                              PMT07090
      END IF                                                             PMT07091
      UINV=1./UPL                                                        PMT07095
C                                                                        PMT07100
C  DEFINE EMISSION RATES (SOURCE STRENGTHS) OF POLLUTANT SPECIES,        PMT07110
C    AND NONDIMENSIONAL DEPOSITION AND SEDIMENTATION PARAMETERS.         PMT07120
      UINV1=UINV/100.                                                    PMT07130
C                                                                        PMT07140
C     ISPEC = 1 OR 2 OR 3                                                PMT07150
      Q1=EP(I,1)                                                         PMT07160
      VDC1=VD1*UINV1                                                     PMT07170
      WC1=W1*UINV1                                                       PMT07180
      V11=VDC1-0.5*WC1                                                   PMT07190
      V21=VDC1-WC1                                                       PMT07200
      IF(V21.EQ.0.) GO TO 251                                            PMT07210
      R11=V11/V21                                                        PMT07220
      R21=0.5*WC1/V21                                                    PMT07230
  251 IF(ISPEC.EQ.1) GO TO 255                                           PMT07240
C                                                                        PMT07250
C     ISPEC = 2 OR 3                                                     PMT07260
      Q2=EP(I,2)                                                         PMT07270
      VDC2=VD2*UINV1                                                     PMT07280
      WC2=W2*UINV1                                                       PMT07290
      V12=VDC2-0.5*WC2                                                   PMT07300
      V22=VDC2-WC2                                                       PMT07310
      IF(V22.EQ.0.) GO TO 253                                            PMT07320
      R12=V12/V22                                                        PMT07330
      R22=0.5*WC2/V22                                                    PMT07340
  253 IF(ISPEC.EQ.2) GO TO 257                                           PMT07350
C                                                                        PMT07360
C     ISPEC = 3                                                          PMT07370
      IF(Q1.EQ.0.) Q1=1.E-6                                              PMT07380
      Q2Q1=Q2/Q1                                                         PMT07390
      V13=V11-0.5*(WC1-WC2)                                              PMT07400
      IF(V21.EQ.0.) GO TO 255                                            PMT07410
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      R13=V13/V21                                                       PMT07420
      R23=0.5*WC2/V21                                                   PMT07430
C                                                                       PMT07440
C     ISPEC = 1 OR 3                                                    PMT07450
  255 UTAUC=TAUC*UPL                                                    PMT07460
  257 KLID=0                                                            PMT07470
C                                                                       PMT07480
C                                                                       PMT07490
C *** PEAK EFFECTIVE SOURCE HEIGHT CALCULATIONS.                        PMT07500
C                                                                       PMT07510
C  CALL SUBROUTINE RISE WITH IRISE=2 TO GET PEAK EFFECTIVE SOURCE       PMT07520
C    HEIGHT, ESH(2).                                                    PMT07530
C                                                                       PMT07540
      IRISE=2                                                           PMT07550
C     ************                                                      PMT07560
      CALL RISE                                                         PMT07570
C     ************                                                      PMT07580
      IRISE=1                                                           PMT07590
C                                                                       PMT07600
C  CALCULATE DISTANCE AT WHICH PLUME REACHES MAXIMUM HEIGHT (PEAK).     PMT07610
C                                                                       PMT07620
      IF(IBUOY.EQ.0) GO TO 263                                          PMT07630
      IF(ISC.LT.5) GO TO 261                                            PMT07640
      PEAK=0.00207148/(UINV*SQRT(DTDZ(ISC-4)*9.8/TA(ISCEN)))            PMT07650
      GO TO 265                                                         PMT07660
  261 PEAK=0.001*XS                                                     PMT07670
      GO TO 265                                                         PMT07680
  263 PEAK= 0.                                                          PMT07690
      IF(ISC.GE.5) GO TO 265                                            PMT07700
      IF(ABS(VP(I)).LT..000001) GO TO 265                               PMT07710
      PEAK=(0.004*UINV*DP(I)*(VP(I) + 3./UINV)**2)/VP(I)                PMT07720
C                                                                       PMT07730
  265 IF(NINPEN.EQ.0) GO TO 264                                         PMT07740
      IF(ISC.GE.5.OR.IBUOY.EQ.0) GO TO 264                              PMT07750
      GO TO 267                                                         PMT07760
C                                                                       PMT07770
C  STANDARD TREATMENT OF PLUME PENETRATION ABOVE MIXING HEIGHT:         PMT07780
C     IF MAXIMUM EFFECTIVE SOURCE HEIGHT EXCEEDS THE MIXING HEIGHT,     PMT07790
C     PLUME ESCAPES THE MIXED LAYER, AND SOURCE IS IGNORED.             PMT07800
  264 IF(NPRINT.EQ.0) GO TO 266                                         PMT07810
      IF(NWDOPT.LE.1.OR.IWDOPT.LE.1) WRITE(IWR,1010)                    PMT07820
     1 I,XP(I),YP(I),Q1,Q2,HP(I),DP(I),VP(I),TP(I),PRL(1,IBUOY+1),      PMT07830
     2 PRL(2,IBUOY+1),DWL(IDWN),DWL(IDWN+1),UPL,ESH(2)                  PMT07840
  266 IF(ESH(2).GT.HMIX(ISCEN)) GO TO 600                               PMT07850
      GO TO 275                                                         PMT07860
C                                                                       PMT07870
C  NEW SCHEMES TO ACCOUNT FOR PLUME PENETRATION OF ELEVATED STABLE      PMT07880
C     LAYER FOR UNSTABLE/NEUTRAL ATMOSPHERE & BUOYANCY-DOMINATED PLUME. PMT07890
  267 PPF=0.                                                            PMT07900
      IPPF=0                                                            PMT07910
      ZIP=HMIX(ISCEN)-HP(I)                                             PMT07920
C     HPEN IS THE MINIMUM EFFECTIVE PLUME CENTERLINE HEIGHT NECESSAY TO PMT07930
C     CONSIDER PENETRATION.                                             PMT07940
      HPEN=HP(I)+2.*ZIP/3.                                              PMT07950
      IF(ESH(2).LT.HPEN) GO TO 270                                      PMT07960
C                                                                       PMT07970
C     ESTIMATE MAXIMUM PLUME RISE ASSUMING THAT THE MIXED LAYER IS      PMT07980
C     STABLY-STRATIFIED WITH THE SAME POT.TEMP.GRADIENT AS THAT IN THE  PMT07990
C     ELEVATED STABLE LAYER.  THIS IS A SIMPLE, CONSERVATIVE APPROACH   PMT08000
C     SINCE THE ACTUAL PLUME RISE WILL BE GREATER.                      PMT08010
      SI=9.8*DTDZI(ISCEN)/TA(ISCEN)                                     PMT08020
      DELHP=2.6*(EFF*UINV/SI)**0.333333                                 PMT08030
C                                                                       PMT08040
C     CALCULATE PLUME PENETRATION FRACTION (PPF) DEFINED AS THE RATIO   PMT08050
C     OF DEPTH OF PLUME ABOVE THE MIXING HEIGHT, (1.5*DELHP - ZIP),     PMT08060
C     TO THE TOTAL PLUME DEPTH, (DELHP).                                PMT08070
      PPF=1.5-ZIP/DELHP                                                 PMT08080
C                                                                       PMT08090
C     COMPLETE PENETRATION (PPF=1.): THE ENTIRE PLUME ESCAPES THE MIXED PMT08100
C     LAYER. IGNORE THIS SOURCE SINCE IT DOES NOT CONTRIBUTE TO THE GLC.PMT08110
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      IF (PPF.GT.0.999) GO TO 268                                       PMT08120
      GO TO 269                                                         PMT08130
  268 IPPF=1                                                            PMT08140
      PPF=1.                                                            PMT08150
      Q1=0.                                                             PMT08160
      IF(ISPEC.GT.1) Q2=0.                                              PMT08170
      GO TO 270                                                         PMT08180
C                                                                       PMT08190
C     NO PENETRATION (PPF=0.): THE ENTIRE PLUME REMAINS WITHIN THE MIXEDPMT08200
C     LAYER. SET MAXIMUM EFFECTIVE STACK HEIGHT AS EQUAL TO HPEN.       PMT08210
  269 IF(PPF.LT.0.001) PPF=0.                                           PMT08220
C                                                                       PMT08230
C     PARTIAL PENETRATION (0. < PPF < 1.): CALCULATE THE NEW MAXIMUM    PMT08240
C     EFFECTIVE STACK HEIGHT.  THIS IS THE HEIGHT OF CENTERLINE OF THE  PMT08250
C     PLUME FRACTION REMAINING WITHIN THE MIXED LAYER.                  PMT08260
      RATP=(1.-0.5*PPF)/(1.5-PPF)                                       PMT08270
      ESH(2)=HP(I)+ZIP*RATP                                             PMT08280
C                                                                       PMT08290
C     DETERMINE DOWNWIND DISTANCE (PEAK) IN KILOMETERS WHERE THIS       PMT08300
C     MAXIMUM HEIGHT OCCURS.                                            PMT08310
      PEAK=.001*((RATP*ZIP/(1.6*UINV))**1.5)/SQRT(EFF)                  PMT08320
C     REDEFINE THE SOURCE STRENGTH SO THAT ONLY (1.-PPF) FRACTION OF THEPMT08330
C     PLUME MATERIAL REMAINING WITHIN MIXED LAYER CONTRIBUTES TO THE GLCPMT08340
      Q1=(1.-PPF)*Q1                                                    PMT08350
      IF(ISPEC.EQ.1) GO TO 270                                          PMT08360
      Q2=(1.-PPF)*Q2                                                    PMT08370
C                                                                       PMT08380
C     PRINT CALCULATED PLUME RISE PARAMETERS.                           PMT08390
  270 IF(NPRINT.EQ.0) GO TO 271                                         PMT08400
      IF(NWDOPT.LE.1.OR.IWDOPT.LE.1) WRITE(IWR,1012)                    PMT08410
     1 I,XP(I),YP(I),Q1,Q2,HP(I),DP(I),VP(I),TP(I),PRL(1,IBUOY+1),      PMT08420
     2 PRL(2,IBUOY+1),DWL(IDWN),DWL(IDWN+1),UPL,ESH(2),PPF              PMT08430
  271 IF(IPPF.EQ.1) GO TO 600                                           PMT08440
C                                                                       PMT08450
C                                                                       PMT08460
C  SET LIMITS (XMIN,XMAX,YMIN,YMAX) ON PORTION OF RECEPTOR GRID         PMT08470
C    EXAMINED FOR EACH SOURCE. THE EXTENT OF THIS PORTION DEPENDS       PMT08480
C    ON SOURCE LOCATION, GRID DIMENSIONS, AND WIND DIRECTION.           PMT08490
C                                                                       PMT08500
275   XMAX= XB2                                                         PMT08510
      XMIN= XB1                                                         PMT08520
      YMAX= YB2                                                         PMT08530
      YMIN= YB1                                                         PMT08540
      IF(XP(I)+50.0.LT.XB2) XMAX= XP(I) + 50.                           PMT08550
      IF(XP(I)-50.0.GT.XB1) XMIN= XP(I) - 50.                           PMT08560
      IF(YP(I)+50.0.LT.YB2) YMAX= YP(I) + 50.                           PMT08570
      IF(YP(I)-50.0.GT.YB1) YMIN= YP(I) - 50.                           PMT08580
C                                                                       PMT08590
      DO 242 II=1,2                                                     PMT08600
      FANGC=FLOAT(2*(II-1)+1)*PI2                                       PMT08610
      DIF1=ABS(ABS(WDPANG)-FANGC)                                       PMT08620
      DIF2=ABS(ABS(WDMANG)-FANGC)                                       PMT08630
      IF(DIF1.LT..001) WDPANG=WDPANG+.001                               PMT08640
      IF(DIF2.LT..001) WDMANG=WDMANG-.001                               PMT08650
242   CONTINUE                                                          PMT08660
C                                                                       PMT08670
      GO TO (280,285,290,295,300,305,310,315),IFLAG                     PMT08680
280   IF(WDPANG.GT.3.14)GOTO282                                         PMT08690
      IF(WDMANG.LT.0)GOTO284                                            PMT08700
      YMIN=YP(I)                                                        PMT08710
      XL1=XP(I)+(YB2-YP(I))/TAN(WDPANG)                                 PMT08720
      IF(XL1.GT.XMIN)XMIN=XL1                                           PMT08730
      IF(XL1.GT.XP(I))XMIN=XP(I)                                        PMT08740
      XL2=XP(I)+(YB2-YP(I))/TAN(WDMANG)                                 PMT08750
      IF(XL2.LT.XMAX)XMAX=XL2                                           PMT08760
      IF(XL2.LT.XP(I))XMAX=XP(I)                                        PMT08770
      GOTO320                                                           PMT08780
282   YMIN=YP(I)+(XB1-XP(I))*TAN(WDPANG)                                PMT08790
      XMAX=XP(I)+(YB2-YP(I))/TAN(WDMANG)                                PMT08800
      GOTO320                                                           PMT08810
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284   YMIN=YP(I)+(XB2-XP(I))*TAN(WDMANG)                          PMT08820
      XMIN=XP(I)+(YB2-YP(I))/TAN(WDPANG)                          PMT08830
      GOTO320                                                     PMT08840
285   XL1=XP(I)+(YB2-YP(I))/TAN(WDPANG)                           PMT08850
      IF(XL1.GT.XMIN)XMIN=XL1                                     PMT08860
      IF(XL1.GT.XP(I))XMIN=XP(I)                                  PMT08870
      YL1=YP(I)+(XB2-XP(I))*TAN(WDMANG)                           PMT08880
      IF(YL1.GT.YMIN)YMIN=YL1                                     PMT08890
      IF(YL1.GT.YP(I))YMIN=YP(I)                                  PMT08900
      GOTO320                                                     PMT08910
290   IF(WDPANG.GT.1.57.AND.WDMANG.LT.0.)GOTO292                  PMT08920
      IF(WDPANG.GT.6.28.AND.WDMANG.LT.4.712)GOTO294               PMT08930
      XMIN=XP(I)                                                  PMT08940
      YL1=YP(I)+(XB2-XP(I))*TAN(WDMANG)                           PMT08950
      IF(YL1.GT.YMIN)YMIN=YL1                                     PMT08960
      IF(YL1.GT.YP(I))YMIN=YP(I)                                  PMT08970
      YL2=YP(I)+(XB2-XP(I))*TAN(WDPANG)                           PMT08980
      IF(YL2.LT.YMAX)YMAX=YL2                                     PMT08990
      IF(YL2.LT.YP(I))YMAX=YP(I)                                  PMT09000
      GOTO320                                                     PMT09010
292   YMIN=YP(I)+(XB2-XP(I))*TAN(WDMANG)                          PMT09020
      XMIN=XP(I)+(YB2-YP(I))/TAN(WDPANG)                          PMT09030
      GOTO320                                                     PMT09040
294   XMIN=XP(I)+(YB1-YP(I))/TAN(WDMANG)                          PMT09050
      YMAX=YP(I)+(XB2-XP(I))*TAN(WDPANG)                          PMT09060
      GOTO320                                                     PMT09070
295   XL1=XP(I)+(YB1-YP(I))/TAN(WDMANG)                           PMT09080
      IF(XL1.GT.XMIN)XMIN=XL1                                     PMT09090
      IF(XL1.GT.XP(I))XMIN=XP(I)                                  PMT09100
      YL2=YP(I)+(XB2-XP(I))*TAN(WDPANG)                           PMT09110
      IF(YL2.LT.YMAX)YMAX=YL2                                     PMT09120
      IF(YL2.LT.YP(I))YMAX=YP(I)                                  PMT09130
      GOTO320                                                     PMT09140
300   IF(WDPANG.GT.6.28)GOTO302                                   PMT09150
      IF(WDMANG.LT.3.14)GOTO304                                   PMT09160
      YMAX=YP(I)                                                  PMT09170
      XL1=XP(I)+(YB1-YP(I))/TAN(WDMANG)                           PMT09180
      IF(XL1.GT.XMIN)XMIN=XL1                                     PMT09190
      IF(XL1.GT.XP(I))XMIN=XP(I)                                  PMT09200
      XL2=XP(I)+(YB1-YP(I))/TAN(WDPANG)                           PMT09210
      IF(XL2.LT.XMAX)XMAX=XL2                                     PMT09220
      IF(XL2.LT.XP(I))XMAX=XP(I)                                  PMT09230
      GOTO320                                                     PMT09240
302   YMAX=YP(I)+(XB2-XP(I))*TAN(WDPANG)                          PMT09250
      XMIN=XP(I)+(YB1-YP(I))/TAN(WDMANG)                          PMT09260
      GOTO320                                                     PMT09270
304   YMAX=YP(I)+(XB1-XP(I))*TAN(WDMANG)                          PMT09280
      XMAN=XP(I)+(YB1-YP(I))/TAN(WDPANG)                          PMT09290
      GOTO320                                                     PMT09300
305   YL2=YP(I)+(XB1-XP(I))*TAN(WDMANG)                           PMT09310
      IF(YL2.LT.YMAX)YMAX=YL2                                     PMT09320
      IF(YL2.LT.YP(I))YMAX=YP(I)                                  PMT09330
      XL2=XP(I)+(YB1-YP(I))/TAN(WDPANG)                           PMT09340
      IF(XL2.LT.XMAX)XMAX=XL2                                     PMT09350
      IF(XL2.LT.XP(I))XMAX=XP(I)                                  PMT09360
      GOTO320                                                     PMT09370
310   IF(WDMANG.LT.1.57)GOTO312                                   PMT09380
      IF(WDPANG.GT.4.712)GOTO314                                  PMT09390
      XMAX=XP(I)                                                  PMT09400
      YL1=YP(I)+(XB1-XP(I))*TAN(WDPANG)                           PMT09410
      IF(YL1.GT.YMIN)YMIN=YL1                                     PMT09420
      IF(YL1.GT.YP(I))YMIN=YP(I)                                  PMT09430
      YL2=YP(I)+(XB1-XP(I))*TAN(WDMANG)                           PMT09440
      IF(YL2.LT.YMAX)YMAX=YL2                                     PMT09450
      IF(YL2.LT.YP(I))YMAX=YP(I)                                  PMT09460
      GOTO320                                                     PMT09470
312   XL2=XP(I)+(YB2-YP(I))/TAN(WDMANG)                           PMT09480
      IF(XL2.LT.XMAX)XMAX=XL2                                     PMT09490
      IF(XL2.LT.XP(I))XMAX=XP(I)                                  PMT09500
      YL1=YP(I)+(XB1-XP(I))*TAN(WDPANG)                           PMT09510
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      IF(YL1.GT.YMIN)YMIN=YL1                                           PMT09520
      IF(YL1.GT.YP(I))YMIN=YP(I)                                        PMT09530
      GOTO320                                                           PMT09540
314   XL2=XP(I)+(YB1-YP(I))/TAN(WDPANG)                                 PMT09550
      IF(XL2.LT.XMAX)XMAX=XL2                                           PMT09560
      IF(XL2.LT.XP(I))XMAX=XP(I)                                        PMT09570
      YL2=YP(I)+(XB1-XP(I))*TAN(WDMANG)                                 PMT09580
      IF(YL2.LT.YMAX)YMAX=YL2                                           PMT09590
      IF(YL2.LT.YP(I))YMAX=YP(I)                                        PMT09600
      GOTO320                                                           PMT09610
315   XL2=XP(I)+(YB2-YP(I))/TAN(WDMANG)                                 PMT09620
      IF(XL2.LT.XMAX)XMAX=XL2                                           PMT09630
      IF(XL2.LT.XP(I))XMAX=XP(I)                                        PMT09640
      YL1=YP(I)+(XB1-XP(I))*TAN(WDPANG)                                 PMT09650
      IF(YL1.GT.YMIN)YMIN=YL1                                           PMT09660
      IF(YL1.GT.YP(I))YMIN=YP(I)                                        PMT09670
      GOTO320                                                           PMT09680
320   IF(XMIN.GT.XB2.OR.XMAX.LT.XB1.OR.YMIN.GT.YB2.OR.YMAX.LT.YB1)      PMT09690
     1 GO TO 600                                                        PMT09700
      IF(XMIN.LT.XB1) XMIN=XB1                                          PMT09710
      IF(XMAX.GT.XB2) XMAX=XB2                                          PMT09720
      IF(YMIN.LT.YB1) YMIN=YB1                                          PMT09730
      IF(YMAX.GT.YB2) YMAX=YB2                                          PMT09740
C                                                                       PMT09750
C  DETERMINE THE RANGE OF RECEPTOR GRID ROW AND COLUMN NUMBERS (LXMAX,  PMT09760
C    LXMIN,LYMAX,LYMIN) CORRESPONDING TO XMAX, ETC. ABOVE -            PMT09770
C                                                                       PMT09780
      LXMAX= (XMAX-XSWC)/GRID + 1.                                      PMT09790
      LXMIN= (XMIN-XSWC)/GRID + 1.                                      PMT09800
      LYMAX= (YMAX-YSWC)/GRID + 1.                                      PMT09810
      LYMIN= (YMIN-YSWC)/GRID + 1.                                      PMT09820
C                                                                       PMT09830
C     START LOOP ON ALL AFFECTED RECEPTORS.                             PMT09840
      DO 500 IX=LXMIN,LXMAX                                             PMT09850
      XI=IX                                                             PMT09860
      XG= XSWC + (XI-0.5)*GRID                                          PMT09870
      XD= XG - XP(I) + 0.00001                                          PMT09880
      XDSQ=XD*XD                                                        PMT09890
      DO 500 JY=LYMIN,LYMAX                                             PMT09900
      YJ=JY                                                             PMT09910
      YG= YSWC + (YJ-0.5)*GRID                                          PMT09920
      YD= YG - YP(I) + 0.00001                                          PMT09930
C  DSQ= SQUARE OF SOURCE-RECEPTOR DISTANCE. IF SOURCE-RECEPTOR DISTANCE PMT09940
C    IS GREATER THAN 50 KM., RECEPTOR IS SKIPPED.                       PMT09950
      DSQ= XDSQ + YD*YD                                                 PMT09960
      IF(DSQ.GT.2500.) GO TO 500                                        PMT09970
      DELTA= ATAN(XD/YD)                                                PMT09980
      IF(DELTA.LT.0.) DELTA = DELTA + 3.1415927                         PMT09990
      IF(XD.LT.0.) DELTA = DELTA + 3.1415927                            PMT10000
      DELTA= ABS(DELTA - WVEC)                                          PMT10010
      IF(DELTA.GT.3.1415927) DELTA= ABS(6.2831853 - DELTA)              PMT10020
      DIF1=ABS(DELTA-PI2)                                               PMT10030
      IF(DIF1.LT..001) DELTA=DELTA+.001                                 PMT10040
C  IF THE CROSSWIND ANGLE (DELTA) EXCEEDS A LIMITING VALUE WHICH        PMT10050
C    DEPENDS ON STABILITY CLASS (ANGLIM), THE RECEPTOR IS SKIPPED.      PMT10060
C      ANGLIM = 43.,43.,33.,25.,18., AND 18. DEGREES FOR 1-HOUR AVERAGE PMT10070
C      FOR STABILITY CLASSES A, B, C, D, E, AND F RESPECTIVELY.         PMT10080
C                                                                       PMT10090
      IF(DELTA.GT.ANGLIM(ISC)) GO TO 500                                PMT10100
C  DELTA IS THE ANGLE BETWEEN THE WIND VECTOR AND THE SOURCE-RECEPTOR   PMT10110
C    DIRECTION.  THE DOWNWIND DISTANCE USED IN THE GAUSSIAN PLUME       PMT10120
C    EQUATION IS=   DIST= SQRT(DSQ)*COS(DELTA).                         PMT10130
      DIST=SQRT(DSQ)*COS(DELTA)                                         PMT10140
      IF(DIST.LT.0.002) GO TO 500                                       PMT10150
C                                                                       PMT10160
C                                                                       PMT10170
C *** DETERMINE PROBABILITY DENSITIES OF VERTICAL DISTRIBUTIONS         PMT10310
C     OF  SPECIES-1 AND SPECIES-2 POLLUTANT CONCENTRATIONS.             PMT10320
C                                                                       PMT10330
      IF(DIST.GT.D47) GO TO 330                                         PMT10340
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C **** NEAR-SOURCE REGION (DIST .LE. D47).                              PMT10350
C     CALCULATE QZC1 AND QZC2 FROM QZCAL (MODULE M=1).                  PMT10360
C     ************                                                      PMT10370
      CALL QZCAL                                                        PMT10380
C     ************                                                      PMT10390
      GO TO 350                                                         PMT10400
C                                                                       PMT10410
  330 IF(DIST.LT.D80) GO TO 331                                         PMT10420
C **** WELL-MIXED REGION (DIST .GE. D80).                               PMT10430
C     CALCULATE QZC1 AND QZC2 FROM QZCAL (MODULE M=2).                  PMT10440
C     ************                                                      PMT10450
      CALL QZCAL                                                        PMT10460
C     ************                                                      PMT10470
      GO TO 350                                                         PMT10480
C                                                                       PMT10490
  331 IF(KLID.EQ.1) GO TO 337                                           PMT10500
C     CALCULATE QZC1 AND QZC2 FOR POLLUTANT SPECIES                     PMT10510
C     AT DIST=D47 AND DIST=D80 FOR USE IN INTERPOLATION                 PMT10520
C     IN PLUME-TRAPPING REGION.                                         PMT10530
      DUMX=DIST                                                         PMT10540
      DIST=D47                                                          PMT10550
C     ************                                                      PMT10560
      CALL QZCAL                                                        PMT10570
C     ************                                                      PMT10580
      QZC11=QZC1                                                        PMT10590
      IF(ISPEC.EQ.1) GO TO 332                                          PMT10600
      QZC21=QZC2                                                        PMT10610
C                                                                       PMT10620
  332 DIST=D80                                                          PMT10630
C     ************                                                      PMT10640
      CALL QZCAL                                                        PMT10650
C     ************                                                      PMT10660
      QZC12=QZC1                                                        PMT10670
      IRC1=1                                                            PMT10680
      IF(QZC11.EQ.0.OR.QZC12.EQ.0.) IRC1=0                              PMT10690
      IF(ISPEC.EQ.1) GO TO 333                                          PMT10700
      QZC22=QZC2                                                        PMT10710
      IRC2=1                                                            PMT10720
      IF(QZC21.EQ.0.OR.QZC22.EQ.0.) IRC2=0                              PMT10730
C                                                                       PMT10740
  333 KLID=1                                                            PMT10750
      DIST=DUMX                                                         PMT10760
      IF(IRC1.EQ.0) GO TO 334                                           PMT10770
      DIFX1=ALOG(D80/D47)                                               PMT10780
      DIFC1=ALOG(QZC12/QZC11)                                           PMT10790
      GO TO 335                                                         PMT10800
  334 DIFC1=QZC12-QZC11                                                 PMT10810
  335 IF(ISPEC.EQ.1) GO TO 337                                          PMT10820
      IF(IRC2.EQ.0) GO TO 336                                           PMT10830
      DIFX2=ALOG(D80/D47)                                               PMT10840
      DIFC2=ALOG(QZC22/QZC21)                                           PMT10850
      GO TO 337                                                         PMT10860
  336 DIFC2=QZC22-QZC21                                                 PMT10870
C                                                                       PMT10880
C **** PLUME-TRAPPING REGION (D47 < DIST < D80).                        PMT10890
C     CALCULATE QZC1 AND QZC2 BY LINEAR INTERPOLATION                   PMT10900
C     (BETWEEN VALUES AT DIST=D47 AND DIST=D80) ON                      PMT10910
C     A LOG-LOG PLOT OF QZC VERSUS DOWNWIND DISTANCE.                   PMT10920
C     IF EITHER OF THE QZC VALUES AT D47 AND D80 ARE                    PMT10930
C     ZERO, USE A LINEAR PLOT FOR INTERPOLATION.                        PMT10940
  337 IF(IRC1.EQ.0) GO TO 338                                           PMT10950
      RATX1=ALOG(DIST/D47)/DIFX1                                        PMT10960
      QZC1L=ALOG(QZC11)+RATX1*DIFC1                                     PMT10970
      QZC1=EXP(QZC1L)                                                   PMT10980
      GO TO 339                                                         PMT10990
  338 RATX1=(DIST-D47)/D8047                                            PMT11000
      QZC1=QZC11+RATX1*DIFC1                                            PMT11010
  339 IF(ISPEC.EQ.1) GO TO 350                                          PMT11020
C                                                                       PMT11030
      IF(IRC2.EQ.0) GO TO 340                                           PMT11040
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      RATX2=ALOG(DIST/D47)/DIFX2                                        PMT11050
      QZC2L=ALOG(QZC21)+RATX2*DIFC2                                     PMT11060
      QZC2=EXP(QZC2L)                                                   PMT11070
      GO TO 350                                                         PMT11080
  340 RATX2=(DIST-D47)/D8047                                            PMT11090
      QZC2=QZC21+RATX2*DIFC2                                            PMT11100
C                                                                       PMT11110
C *** DETERMINE PROBABILITY DENSITY OF CROSSWIND DISTRIBUTION           PMT10180
C     OF CONCENTRATIONS.                                                PMT10190
C                                                                       PMT10200
350   XM=DIST*1000.                                                     PMT10210
      SIGY=AY(ISC)*XM/(SQRT(1.+.0004*XM))                               PMT10220
C. CHECK FOR BID OPTION.  OMIT BID IF NBID=0.                           PMT10221
      IF(NBID.EQ.0) GO TO 351                                           PMT10222
C. CONSIDER BOUYANCY INDUCED DISPERSION. DH IS SAME AS DELTAH.          PMT10223
      DH=HGT-HPRIME                                                     PMT10224
      SIGB=DH/3.5                                                       PMT10225
      SIGB=SIGB*SIGB                                                    PMT10225
      SIGY=SQRT(SIGY*SIGY + SIGB)                                       PMT10226
351   YM=XM*TAN(DELTA)                                                  PMT10230
      DUMY=YM/SIGY                                                      PMT10240
      ARG=0.5*DUMY*DUMY                                                 PMT10250
      IF(ARG.GE.EXPMIN) GO TO 500                                       PMT10260
      EXPA=EXP(-ARG)                                                    PMT10270
      PYC=(A1B/SIGY)*EXPA                                               PMT10280
C                                                                       PMT10290
C                                                                       PMT10300
C                                                                       PMT11120
C                                                                       PMT11130
C     CALCULATE GROUND-LEVEL CONCENTRATIONS CONC (MICROGRAMS PER CUBIC  PMT11140
C     METER) AND SURFACE DEPOSITION FLUX SDF (MICROGRAMS PER SQUARE     PMT11150
C     METER PER HOUR) OF POLLUTANTS AT RECEPTOR IN COLUMN IX, ROW JY    PMT11160
C     OF THE RECEPTOR GRID DUE TO POINT SOURCE I.                       PMT11170
C                                                                       PMT11180
C     ISPEC = 1 OR 2 OR 3                                               PMT11190
      C1=Q1*UINV*PYC*QZC1                                               PMT11200
      IF(NCSOPT.EQ.0) GO TO 355                                         PMT11210
      CALL WORST(IX,JY,C1,1)                                            PMT11220
C                                                                       PMT11230
  355 CINC1=C1*STCONV                                                   PMT11240
      CONC(IX,JY,1)=CONC(IX,JY,1)+CINC1                                 PMT11250
      SDF(IX,JY,1)=SDF(IX,JY,1)+VD136*CINC1                             PMT11260
      IF(ISPEC.EQ.1) GO TO 370                                          PMT11270
      IF(ISPEC.EQ.3) GO TO 360                                          PMT11280
C                                                                       PMT11290
C     ISPEC = 2                                                         PMT11300
      C2=Q2*UINV*PYC*QZC2                                               PMT11310
      GO TO 363                                                         PMT11320
C                                                                       PMT11330
C     ISPEC = 3                                                         PMT11340
  360 C2=Q1*UINV*PYC*QZC2                                               PMT11350
C                                                                       PMT11360
  363 IF(NCSOPT.EQ.0) GO TO 365                                         PMT11370
      CALL WORST(IX,JY,C2,2)                                            PMT11380
C                                                                       PMT11390
  365 CINC2=C2*STCONV                                                   PMT11400
      CONC(IX,JY,2)=CONC(IX,JY,2)+CINC2                                 PMT11410
      SDF(IX,JY,2)=SDF(IX,JY,2)+VD236*CINC2                             PMT11420
  370 CONTINUE                                                          PMT11430
C                                                                       PMT11440
500   CONTINUE                                                          PMT11450
C     END LOOP ON ALL AFFECTED RECEPTORS.                               PMT11460
C                                                                       PMT11470
600   CONTINUE                                                          PMT11480
C     END LOOP ON ALL POINT SOURCES.                                    PMT11490
C                                                                       PMT11500
C                                                                       PMT11510
C                                                                       PMT11520
C *** PRINT OUTPUT.                                                     PMT11530
C                                                                       PMT11540
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C     OUTPUT AT END OF EACH AVERAGING-PERIOD.                           PMT11550
C                                                                       PMT11560
C     TIME AVERAGING:  NTOPT=2 OR 3                                     PMT11570
C       IF NOT LAST SCENARIO, GO TO 100 FOR THE NEXT SCENARIO.          PMT11580
C       IF LAST SCENARIO, CALL OUTMOD TO PRINT OUTPUT FOR NLIST, NTAPE, PMT11590
C         AND NARRAY OPTIONS, AND THEN CALL MAXOUT TO PRINT OUTPUT      PMT11600
C         FOR NMAX.                                                     PMT11610
C                                                                       PMT11620
C     OUTPUT AT END OF EACH SCENARIO (OR SUB-SCENARIO)                  PMT11630
C     NO TIME AVERAGING: NTOPT=1                                        PMT11640
C       AT END OF EACH SCENARIO (OR SUB-SCENARIO WHEN NWDOPT.GT.1),     PMT11650
C         CALL OUTMOD TO PRINT OUTPUT FOR NCSOPT, NLIST, NTAPE,         PMT11660
C         AND NARRAY OPTIONS.                                           PMT11670
C       IF LAST SCENARIO (AND LAST SUB-SCENARIO WHEN NWDOPT.GT.1),      PMT11680
C         CALL MAXOUT TO PRINT OUTPUT FOR NMAX OPTION.                  PMT11690
C       IF NOT LAST SCENARIO, GO TO 100 FOR THE THE NEXT SCENARIO       PMT11700
C         OR SUB-SCENARIO.                                              PMT11710
C                                                                       PMT11720
  603 IF(NTOPT.EQ.1) GO TO 620                                          PMT11730
C                                                                       PMT11740
C     TIME AVERAGING: NTOPT=2 OR 3                                      PMT11750
      IF(ISCEN.NE.NSCEN) GO TO 100                                      PMT11760
C     ************                                                      PMT11770
      CALL OUTMOD                                                       PMT11780
C     ************                                                      PMT11790
      GO TO 999                                                         PMT11800
C                                                                       PMT11810
C     NO TIME AVERAGING: NTOPT=1                                        PMT11820
C     ************                                                      PMT11830
  620 CALL OUTMOD                                                       PMT11840
C     ************                                                      PMT11850
      IF(ISCEN.NE.NSCEN) GO TO 100                                      PMT11860
      IF(NWDOPT.LE.1) GO TO 999                                         PMT11870
      IF(IWDOPT.LT.4) GO TO 100                                         PMT11880
C                                                                       PMT11890
C     ************                                                      PMT11900
  999 IF(NMAX.GT.0) CALL MAXOUT                                         PMT11910
C     ************                                                      PMT11920
C                                                                       PMT11930
      CALL WAUDIT
      STOP                                                              PMT11940
C                                                                       PMT11950
C                                                                       PMT11960
 1001 FORMAT(1H1,37X,'POLLUTION EPISODIC MODEL (PEM-2)'///4X,'OUTPUT:  'PMT11970
     1,20A4//4X,'SCENARIO',I2,4X,'POINT SOURCE PLUME RISE CALCULATIONS'/PMT11980
     221X,'MIXING HEIGHT: HMIX=',F7.2,' M'/                             PMT11990
     321X,'POTENTIAL TEMPERATURE GRADIENT ABOVE MIXING HEIGHT=',        PMT12000
     4F6.4,' DEG/M'/)                                                   PMT12010
 1003 FORMAT(11X,'SOURCE',6X,'EMISSION RATES',2X,'STACK',4X,'EXIT',     PMT12020
     15X,'EXIT',4X,'EXIT',17X,'WIND SPEED AT',2X,'MAX.EFF.',6X,'PLUME',/PMT12030
     2' POINT',3X,'COORDINATES',3X,'POL-1',3X,'POL-2',3X,'HEIGHT',      PMT12040
     3' DIAMETER VELOCITY  TEMP.',5X,'DOMINANT',3X,'STACK HEIGHT 'SOURCEPMT12050
     4 HT.  PENETRATION'/' SOURCE X(KM)   Y(KM)  (G/S)   (G/S)',4X,     PMT12060
     5'(M)',6X,'(M)',4X,'(M/S)  (DEG K)',4X,'INFLUENCE',7X,'(M/S)',8X,  PMT12070
     6'(M)',7X,'FRACTION'/)                                             PMT12080
 1005 FORMAT(1H1,37X,'POLLUTION EPISODIC MODEL (PEM-2)'//4X,'OUTPUT:  ',PMT12090
     120A4//4X,'SCENARIO',I2,4X,'POINT SOURCE PLUME RISE CALCULATIONS'/ PMT12100
     221X,'MIXING HEIGHT: HMIX=',F7.2,' M'/)                            PMT12110
 1007 FORMAT(14X,'SOURCE',8X,'EMISSION RATES',61X,'WIND SPEED AT',4X,   PMT12120
     1 'MAXIMUM',/' POINT',6X,'COORDINATES',4X,'POL-1',6X,'POL-2',4X,   PMT12130
     2 'HEIGHT  DIAMETER  EXIT VEL  EXIT TEMP',6X,'DOMINANT',5X,        PMT12140
     3 'STACK HEIGHT',4X,'EFFECTIVE'/' SOURCE',3X,'X(KM)',4X,'Y(KM)',3X,PMT12150
     4 '(G/S)',6X,'(G/S)',5X,'(M)',6X,'(M)',7X,'(M/S)',4X,'(DEG K)',6X, PMT12160
     5 'INFLUENCE',8X,'(M/S)',6X,'SOURCE HEIGHT(M)'/)                   PMT12170
 1010 FORMAT(1X,I4,2X,F8.2,1X,F8.2,2X,F8.2,2X,F8.2,2X,F7.2,3X,F6.3,3X,  PMT12180
     1 F8.3,3X,F7.2,2X,2A4,1X,2A4,3X,F7.3,8X,F8.2)                      PMT12190
 1012 FORMAT(2X,I3,5(1X,F7.1),3(2X,F6.2),2(1X,2A4),2X,F6.2,             PMT12200
     1 5X,F8.2,8X,F5.3)                                                 PMT12210
      END                                                               PMT12220
C                                                                       PMT12230
```

```
C                                                                       PMT12240
C
      SUBROUTINE QZCAL                                                  PMT12250
C                    SUBROUTINE QZCAL , PART OF PEM-2 (VERSION 84130).  PMT12260
C                                                                       PMT12270
C                                                                       PMT12280
C  SUBROUTINE QZCAL CALCULATES QZC1 AND QZC2,  REPRESENTING THE         PMT12290
C     PROBABLITY DENSITIES OF VERTICAL DISTRIBUTIONS OF CONCENTRATIONS  PMT12300
C     OF POLLUTANT SPECIES 1 AND 2, RESPECTIVELY, AT A GIVEN            PMT12310
C     DISTANCE DOWNWIND OF A POINT SOURCE.                              PMT12320
C                                                                       PMT12330
C                                                                       PMT12340
C *** PEM  ALGORITHMS AND PROGRAM DEVELOPMENT: ---DECEMBER 1982         PMT12350
C *** PEM-2 MODIFICATIONS: DECEMBER 1983                                PMT12360
C                                                                       PMT12370
C     K. SHANKAR RAO, PHYSICAL SCIENTIST                                PMT12380
C     ATMOSPHERIC TURBULENCE AND DIFFUSION LABORATORY (ATDL)            PMT12390
C     NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)            PMT12400
C     U.S. DEPARTMENT OF COMMERCE, P.O. BOX - E                         PMT12410
C     OAK RIDGE, TENNESSEE 37831                                        PMT12420
C                                                                       PMT12430
C     ( THIS WORK WAS DONE UNDER AN INTERAGENCY AGREEMENT               PMT12440
C     BETWEEN THE ENVIRONMENTAL PROTECTION AGENCY AND THE               PMT12450
C     NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION )                 PMT12460
C                                                                       PMT12470
C                                                                       PMT12480
C                                                                       PMT12490
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                  PMT12500
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),       PMT12510
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                 PMT12520
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                         PMT12530
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),              PMT12540
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),          PMT12550
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,                PMT12560
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                   PMT12570
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,                PMT12580
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,      PMT12590
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT12600
C                                                                       PMT12610
      COMMON/PARM1/NPOL,VD1,W1,VD2,W2                                   PMT12620
      COMMON/PARM1A/ICT,TAUC,GAMMA                                      PMT12630
      COMMON/PARM2/ISPEC,UTAUC,Q2Q1,XCT,EXCT                            PMT12640
      COMMON/PARM3/HC,VDC1,WC1,VDC2,WC2                                 PMT12650
      COMMON/PARM4/V11,V21,V12,V22,V13                                  PMT12660
      COMMON/PARM5/D11,D21,D12,D22,D31,D32,D33,D6                       PMT12670
      COMMON/PARM6/R11,R21,R12,R22,R13,R23,R31,R41,R32,R42              PMT12680
      COMMON/PARM7/QZC1,QZC2,HGT                                        PMT12690
      COMMON/BLOCK1/PI,SQPI,SQRT2,A1B,A1C                               PMT12700
      COMMON/BLOCK2/AI,BI,EPSABS,EPSREL,LW,NIW                          PMT12710
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX                                PMT12720
      EXTERNAL FUN1                                                     PMT12730
      REAL*8 FUN1                                                       PMT12740
      REAL*8 WORK(800),AI,BI,EPSABS,EPSREL,RESULT,ABSERR                PMT12750
      DIMENSION IW(102)                                                 PMT12760
C                                                                       PMT12770
C                                                                       PMT12780
C                                                                       PMT12790
      IF(DIST.GE.PEAK) GO TO 5                                          PMT12800
C. TEST FOR GRADUAL PLUME RISE AND BID OPTIONS.                         PMT12801
C. IF DIST IS LESS THAN FINAL RISE, THEN USE GRAD. RISE IF BID SELECTED PMT12802
C. AND USE THE GRADUAL RISE HEIGHT FOR EFFECTIVE PLUME HEIGHT,          PMT12803
C.  OTHERWISE USE FINAL PLUME HEIGHT (ESH(2)).                          PMT12804
C.                                                                      PMT12805
C. OMIT CALL RISE, IF NGPR=1 (I.E. FINAL RISE) AND NBID=0 (I.E. NO BID) PMT12806
      IF(NGPR.EQ.1.AND.NBID.EQ.0) GO TO 5                               PMT12807
C                                                                       PMT12810
C  CALL SUBROUTINE RISE FOR EFFECTIVE SOURCE HEIGHT AT DOWNWIND         PMT12820
C    DISTANCE = DIST, LESS THAN DISTANCE TO MAXIMUM HEIGHT (PEAK).      PMT12830
C     ************                                                      PMT12840
      CALL RISE                                                         PMT12850
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C     ************                                                      PMT12860
      HGT= ESH(1)                                                       PMT12870
      GO TO 6                                                           PMT12880
C                                                                       PMT12890
C  USE MAXIMUM EFFECTIVE SOURCE HEIGHT, SINCE DOWNWIND DISTANCE         PMT12900
C    EXCEEDS THE DISTANCE TO MAXIMUM HEIGHT.                            PMT12910
  5   HGT= ESH(2)                                                       PMT12920
C                                                                       PMT12930
C                                                                       PMT12940
  6   HL=HMIX(ISCEN)                                                    PMT12950
      X=DIST                                                            PMT12960
      XM=X*1000.                                                        PMT12970
      SIGZ= AZ(ISC)*XM*(1.+CZ(ISC)*XM)/(SQRT(1.+BZ(ISC)*XM))            PMT12980
C. CHECK FOR BID OPTION. NBID=1 , BID ON                                PMT12981
      IF(NBID.EQ.0) GO TO 3                                             PMT12982
C.  CONSIDER BOUYANCY INDUCED DISPERSION (BID)                          PMT12983
      DH=HGT-HPRIME                                                     PMT12984
      SIGB=DH/3.5                                                       PMT12985
      SIGB=SIGB*SIGB                                                    PMT12986
      SIGZ=SQRT(SIGZ*SIGZ + SIGB)                                       PMT12987
3     IF(SIGZ.GT.5000.) SIGZ=5000.                                      PMT12990
      SZ=SIGZ                                                           PMT13000
      C2=SQRT2*SZ                                                       PMT13010
      HC=HGT/C2                                                         PMT13020
      IF(NGPR.EQ.1) HC=ESH(2)/C2                                        PMT13021
      XC=XM/C2                                                          PMT13030
C                                                                       PMT13040
C     ISPEC = 1 OR 2 OR 3                                               PMT13050
      D31=2.*V11*XC                                                     PMT13060
      D11=WC1*XC                                                        PMT13070
      D21=D11*D11                                                       PMT13080
      R31=1.+2.*D21                                                     PMT13090
      R41=2.*D11/SQPI                                                   PMT13100
      IF(ISPEC.EQ.1) GO TO 9                                            PMT13110
C                                                                       PMT13120
C     ISPEC = 2 OR 3                                                    PMT13130
      D32=2.*V12*XC                                                     PMT13140
      D12=WC2*XC                                                        PMT13150
      D22=D12*D12                                                       PMT13160
      R32=1.+2.*D22                                                     PMT13170
      R42=2.*D12/SQPI                                                   PMT13180
      IF(ISPEC.EQ.2) GO TO 10                                           PMT13190
C                                                                       PMT13200
C     ISPEC = 3                                                         PMT13210
      D33=2.*V13*XC                                                     PMT13220
      D6=4.*SQPI*(V21-V22)*XC                                           PMT13230
C                                                                       PMT13240
    9 TCC=UTAUC/C2                                                      PMT13250
   10 IF(ICT.EQ.0) XCT=0.                                               PMT13260
      IF(ICT.EQ.1) XCT=XC/TCC                                           PMT13270
      EXCT=EXP(-XCT)                                                    PMT13280
C                                                                       PMT13290
      TERM1=0.                                                          PMT13300
      TERM2=0.                                                          PMT13310
      TERM3=0.                                                          PMT13320
C                                                                       PMT13330
      DUM1=D47+0.001                                                    PMT13340
      DUM2=D80-0.001                                                    PMT13350
      IF(X.LT.DUM1) GO TO 100                                           PMT13360
      IF(X.GT.DUM2) GO TO 200                                           PMT13370
C                                                                       PMT13380
   11 QZC1=0.0                                                          PMT13390
      QZC2=0.0                                                          PMT13400
      RETURN                                                            PMT13410
C                                                                       PMT13420
C                                                                       PMT13430
C **** NEAR-SOURCE REGION (X .LE. D47).                                 PMT13440
C                                                                       PMT13450
  100 M=1                                                               PMT13460
      A1=A1B/SZ                                                         PMT13470
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      C3=HC*HC                                                          PMT13480
      IF(C3.GE.EXPMIN) GO TO 11                                         PMT13490
      A2=1./EXP(C3)                                                     PMT13500
C                                                                       PMT13510
C     ISPEC = 1 OR 2 OR 3                                               PMT13520
C     SPECIES-1 (PRIMARY) POLLUTANT: GAS OR PARTICLES.                  PMT13530
      ETA1=HC+D31                                                       PMT13540
      ETA1SQ=ETA1*ETA1                                                  PMT13550
      IF(ETA1SQ.GT.EXPMAX) CALL ARGCHK(ETA1,ETA1SQ)                     PMT13560
      B11=EXP(ETA1SQ)*ERFC(ETA1)                                        PMT13570
      ALPHA1=A1C*D31*B11                                                PMT13580
      SUM=2.-ALPHA1                                                     PMT13590
      IF(SUM) 115,115,116                                               PMT13600
  115 G21P=0.0                                                          PMT13610
      GO TO 120                                                         PMT13620
  116 IF(WC1.EQ.0.) GO TO 117                                           PMT13630
      BETA1=-2.*D11*HC+D21                                              PMT13640
      CALL EXPO(-BETA1,EBT1)                                            PMT13650
      GO TO 118                                                         PMT13660
  117 EBT1=1.0                                                          PMT13670
  118 G21P=EXCT*EBT1*A2*SUM                                             PMT13680
  120 QZC1=A1*G21P                                                      PMT13690
      IF(ISPEC.EQ.1) RETURN                                             PMT13700
C                                                                       PMT13710
C                                                                       PMT13720
C     ISPEC = 2 OR 3                                                    PMT13730
C     SPECIES-2 (SECONDARY) POLLUTANT: GAS OR PARTICLES.                PMT13740
      ETA2=HC+D32                                                       PMT13750
      ETA2SQ=ETA2*ETA2                                                  PMT13760
      IF(ETA2SQ.GT.EXPMAX) CALL ARGCHK(ETA2,ETA2SQ)                     PMT13770
      B12=EXP(ETA2SQ)*ERFC(ETA2)                                        PMT13780
      ALPHA2=A1C*D32*B12                                                PMT13790
      SUM1=2.-ALPHA2                                                    PMT13800
      IF(ISPEC.EQ.3) GO TO 145                                          PMT13810
C                                                                       PMT13820
C     ISPEC = 2                                                         PMT13830
      IF(SUM1) 135,135,140                                              PMT13840
  135 G22P=0.0                                                          PMT13850
      QZC2=0.0                                                          PMT13860
      RETURN                                                            PMT13870
  140 IF(WC2.EQ.0.) GO TO 141                                           PMT13880
      BETA2=-2.*D12*HC+D22                                              PMT13890
      CALL EXPO(-BETA2,EBT2)                                            PMT13900
      GO TO 142                                                         PMT13910
  141 EBT2=1.0                                                          PMT13920
  142 G22P=EBT2*A2*SUM1                                                 PMT13930
      QZC2=A1*G22P                                                      PMT13940
      RETURN                                                            PMT13950
C                                                                       PMT13960
C     ISPEC = 3                                                         PMT13970
  145 TERM1=(Q2Q1+GAMMA)*A2*SUM1                                        PMT13980
C                                                                       PMT13990
      ETA3=HC+D33                                                       PMT14000
      ETA3SQ=ETA3*ETA3                                                  PMT14010
      IF(ETA3SQ.GT.EXPMAX) CALL ARGCHK(ETA3,ETA3SQ)                     PMT14020
      B13=EXP(ETA3SQ)*ERFC(ETA3)                                        PMT14030
      ALPHA3=A1C*D33*B13                                                PMT14040
      TERM2=-GAMMA*EXCT*A2*(2.-ALPHA3)                                  PMT14050
C                                                                       PMT14060
      IF(V21.EQ.V22) GO TO 150                                          PMT14070
C     COMPUTE INTEGRAL FUNC=F1(XC,0.;HC); FUN1 IS THE INTEGRAND FUNCTIONPMT14080
      CALL D01AJF(FUN1,AI,BI,EPSABS,EPSREL,RESULT,                      PMT14090
     1   ABSERR,WORK,LW,IW,NIW,IFAIL)                                   PMT14100
      RES=RESULT                                                        PMT14110
      FUNC=RES/PI                                                       PMT14120
      TERM3=-GAMMA*D6*FUNC                                              PMT14130
C                                                                       PMT14140
  150 SUMT=TERM1+TERM2+TERM3                                            PMT14150
      IF(SUMT) 155,155,160                                              PMT14160
  155 G22P=0.0                                                          PMT14170
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      QZC2=0.0                                                          PMT14180
      RETURN                                                            PMT14190
  160 IF(WC2.EQ.0.) GO TO 161                                           PMT14200
      BETA2=-2.*D12*HC+D22                                              PMT14210
      CALL EXPO(-BETA2,EBT2)                                            PMT14220
      GO TO 162                                                         PMT14230
  161 EBT2=1.0                                                          PMT14240
  162 G22P=EBT2*SUMT                                                    PMT14250
      QZC2=A1*G22P                                                      PMT14260
      RETURN                                                            PMT14270
C                                                                       PMT14280
C                                                                       PMT14290
C **** WELL-MIXED REGION (X .GE. D80).                                  PMT14300
C                                                                       PMT14310
C     IN THIS REGION, THE CONCENTRATION BELOW THE MIXING HEIGHT IS      PMT14320
C     UNIFORM REGARDLESS OF THE SOURCE OR RECEPTOR HEIGHTS BECAUSE      PMT14330
C     OF THOROUGH MIXING OF POLLUTANT BETWEEN THE GROUND AND THE        PMT14340
C     MIXING HEIGHT.                                                    PMT14350
C                                                                       PMT14360
  200 M=2                                                               PMT14370
      A1A=1000./HL                                                      PMT14380
      CALL PSG4P(G41P,G42P)                                             PMT14390
      QZC1=A1A*G41P                                                     PMT14400
      IF(ISPEC.EQ.1) RETURN                                             PMT14410
      QZC2=A1A*G42P                                                     PMT14420
      RETURN                                                            PMT14430
      END                                                               PMT14440
C                                                                       PMT14450
C                                                                       PMT14460
C
      SUBROUTINE PSG4P(G41P,G42P)                                       PMT14470
C                    SUBROUTINE PSG4P , PART OF PEM-2 (VERSION 84130).  PMT14480
C                                                                       PMT14490
C                                                                       PMT14500
C     THIS SUBROUTINE CALCULATES AND RETURNS VALUES OF G41P AND G42P.   PMT14510
C     THESE ARE NONDIMENSIONAL VERTICALLY-INTEGRATED PROBABILITY        PMT14520
C     DENSITY FUNCTIONS USED IN THE WELL-MIXED REGION CONCENTRATION     PMT14530
C     ALGORITHMS FOR SPECIES-1 AND SPECIES-2, RESPECTIVELY, DOWNWIND    PMT14540
C     OF A POINT SOURCE.  THESE FUNCTIONS ARE INDEPENDENT OF BOTH       PMT14550
C     SOURCE HEIGHT AND RECEPTOR HEIGHT.                                PMT14560
C                                                                       PMT14570
C                                                                       PMT14580
C                                                                       PMT14590
C *** PEM ALGORITHMS AND PROGRAM DEVELOPMENT: --- DECEMBER 1982         PMT14600
C                                                                       PMT14610
C     K. SHANKAR RAO, PHYSICAL SCIENTIST                                PMT14620
C     ATMOSPHERIC TURBULENCE AND DIFFUSION LABORATORY (ATDL)            PMT14630
C     NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)            PMT14640
C     U.S. DEPARTMENT OF COMMERCE, P.O. BOX - E                         PMT14650
C     OAK RIDGE, TENNESSEE 37831                                        PMT14660
C                                                                       PMT14670
C     ( THIS WORK WAS DONE UNDER AN INTERAGENCY AGREEMENT               PMT14680
C     BETWEEN THE ENVIRONMENTAL PROTECTION AGENCY AND THE               PMT14690
C     NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION )                 PMT14700
C                                                                       PMT14710
C                                                                       PMT14720
C                                                                       PMT14730
      EXTERNAL FUN2                                                     PMT14740
      REAL*8 FUN2                                                       PMT14750
      REAL*8 WORK(800),AI,BI,EPSABS,EPSREL,RESULT,ABSERR                PMT14760
      DIMENSION IW(102)                                                 PMT14770
      COMMON/PARM1A/ICT,TAUC,GAMMA                                      PMT14780
      COMMON/PARM2/ISPEC,UTAUC,Q2Q1,XCT,EXCT                            PMT14790
      COMMON/PARM4/V11,V21,V12,V22,V13                                  PMT14800
      COMMON/PARM5/D11,D21,D12,D22,D31,D32,D33,D6                       PMT14810
      COMMON/PARM6/R11,R21,R12,R22,R13,R23,R31,R41,R32,R42              PMT14820
      COMMON/BLOCK1/PI,SQPI,SQRT2,A1B,A1C                               PMT14830
      COMMON/BLOCK2/AI,BI,EPSABS,EPSREL,LW,NIW                          PMT14840
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX                                PMT14850
C                                                                       PMT14860
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C                                                                       PMT14870
C     ISPEC = 1 OR 2 OR 3                                               PMT14880
C***** SPECIES-1 (PRIMARY) POLLUTANT: GAS OR PARTICLES.                 PMT14890
C                                                                       PMT14900
      IF(D21.GT.EXPMAX) CALL ARGCHK(D11,D21)                            PMT14910
      B11=EXP(D21)*ERFC(D11)                                            PMT14920
      IF(V21.EQ.0.) GO TO 201                                           PMT14930
      D31SQ=D31*D31                                                     PMT14940
      IF(D31SQ.GT.EXPMAX) CALL ARGCHK(D31,D31SQ)                        PMT14950
      SUM=R11*(EXP(D31SQ)*ERFC(D31))-R21*B11                            PMT14960
      GO TO 202                                                         PMT14970
  201 SUM=R31*B11-R41                                                   PMT14980
  202 IF(SUM.LT.0.) SUM=0.0                                             PMT14990
      G41P=EXCT*EXP(-D21)*SUM                                           PMT15000
      IF(ISPEC.EQ.1) RETURN                                             PMT15010
C                                                                       PMT15020
C     ISPEC = 2 OR 3                                                    PMT15030
C***** SPECIES-2 (SECONDARY) POLLUTANT: GAS OR PARTICLES.               PMT15040
C                                                                       PMT15050
      IF(D22.GT.EXPMAX) CALL ARGCHK(D12,D22)                            PMT15060
      B12=EXP(D22)*ERFC(D12)                                            PMT15070
      IF(V22.EQ.0.) GO TO 203                                           PMT15080
      D32SQ=D32*D32                                                     PMT15090
      IF(D32SQ.GT.EXPMAX) CALL ARGCHK(D32,D32SQ)                        PMT15100
      SUM1=R12*(EXP(D32SQ)*ERFC(D32))-R22*B12                           PMT15110
      GO TO 204                                                         PMT15120
  203 SUM1=R32*B12-R42                                                  PMT15130
  204 IF(ISPEC.EQ.3) GO TO 205                                          PMT15140
C                                                                       PMT15150
C     ISPEC = 2                                                         PMT15160
      IF(SUM1.LT.0.) SUM1=0.0                                           PMT15170
      G42P=EXP(-D22)*SUM1                                               PMT15180
      RETURN                                                            PMT15190
C                                                                       PMT15200
C     ISPEC = 3                                                         PMT15210
  205 TERM1=(Q2Q1+GAMMA)*SUM1                                           PMT15220
C                                                                       PMT15230
      IF(V21.EQ.0.) GO TO 206                                           PMT15240
      D33SQ=D33*D33                                                     PMT15250
      IF(D33SQ.GT.EXPMAX) CALL ARGCHK(D33,D33SQ)                        PMT15260
      SUM2=R13*(EXP(D33SQ)*ERFC(D33))-R23*B12                           PMT15270
      GO TO 207                                                         PMT15280
  206 SUM2=R32*B12-R42                                                  PMT15290
  207 TERM2=-GAMMA*EXCT*SUM2                                            PMT15300
C                                                                       PMT15310
      IF(V21.EQ.V22) GO TO 208                                          PMT15320
C     COMPUTE INTEGRAL FUNC=F2(XC); FUN2 IS THE INTEGRAND FUNCTION.     PMT15330
      CALL D01AJF(FUN2,AI,BI,EPSABS,EPSREL,RESULT,                      PMT15340
     1  ABSERR,WORK,LW,IW,NIW,IFAIL)                                    PMT15350
      RES=RESULT                                                        PMT15360
      FUNC=RES/(2.*PI)                                                  PMT15370
      TERM3=-GAMMA*D6*FUNC                                              PMT15380
      GO TO 209                                                         PMT15390
  208 TERM3=0.0                                                         PMT15400
C                                                                       PMT15410
  209 SUMT=TERM1+TERM2+TERM3                                            PMT15420
      IF(SUMT.LT.0.) SUMT=0.0                                           PMT15430
      G42P=EXP(-D22)*SUMT                                               PMT15440
      RETURN                                                            PMT15450
      END                                                               PMT15460
C
C                                                                       PMT15470
C                                                                       PMT15480
      DOUBLE PRECISION FUNCTION FUN1(T)                                 PMT15490
C                 REAL*8 FUNCTION FUN1 , PART OF PEM-2 (VERSION 84130). PMT15500
C                                                                       PMT15510
C                                                                       PMT15520
C     INTEGRAND FUNCTION USED IN THE NUMERICAL INTEGRATION IN SUBROUTINEPMT15530
C     QZCAL (FOR POINT SOURCES) IS DEFINED HERE.                        PMT15540
C                                                                       PMT15550
```

```
C
C     PEM-2 ALGORITHMS AND PROGRAM DEVELOPMENT: DECEMBER 1982
C     K. SHANKAR RAO
C     NOAA-ATDL, P.O. BOX-E
C     OAK RIDGE, TENN 37830
C
C
C       FOR UNIVAC-1100
        REAL*8 T
C
      COMMON/PARM2/ISPEC,UTAUC,Q2Q1,XCT,EXCT
      COMMON/PARM3/HC,VDC1,WC1,VDC2,WC2
      COMMON/PARM5/D11,D21,D12,D22,D31,D32,D33,D6
      COMMON/BLOCK1/PI,SQPI,SQRT2,A1B,A1C
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX
C
C
      SQT=SQRT(T)
      SQ1T=SQRT(1.-T)
      HC1=HC/SQT
C
      ARG1=(HC1*HC1)+(T*XCT)
      CALL EXPO(-ARG1,EXP1)
      IF(EXP1.EQ.0.) GO TO 10
      TERM1= EXP1/(SQT*SQ1T)
C
      ETA4=HC1+D33*SQT
      ETA4SQ=ETA4*ETA4
      IF(ETA4SQ.GT.EXPMAX) CALL ARGCHK(ETA4,ETA4SQ)
      TERM2A= EXP(ETA4SQ)*ERFC(ETA4)
      HC1SQ=HC1*HC1
      IF(HC1SQ.GT.EXPMAX) CALL ARGCHK(HC1,HC1SQ)
      TERM2=1.-SQPI*(ETA4-HC1)*TERM2A
      IF(TERM2.LE.0.) GO TO 10
C
      ETA5=D32*SQ1T
      ETA5SQ=ETA5*ETA5
      IF(ETA5SQ.GT.EXPMAX) CALL ARGCHK(ETA5,ETA5SQ)
      TERM3=1.-SQPI*ETA5*(EXP(ETA5SQ)*ERFC(ETA5))
      IF(TERM3.LE.0.) GO TO 10
C
      FUN1=TERM1*TERM2*TERM3
      GO TO 11
   10 FUN1=0.0
   11 RETURN
      END
C
C
C
      DOUBLE PRECISION FUNCTION FUN1A(T)
C                 REAL*8 FUNCTION FUN1A , PART OF PEM-2 (VERSION 84130).
C
C
C     INTEGRAND FUNCTION USED IN THE NUMERICAL INTEGRATION FOR AREA
C     SOURCES (POLLUTANT SPECIES-2) IN FUNCTION FUN4 IS DEFINED HERE.
C
C
C     PEM-2 ALGORITHMS AND PROGRAM DEVELOPMENT: DECEMBER 1983
C     K. SHANKAR RAO, NOAA-ATDL, OAK RIDGE, TENN.
C
C     FOR UNIVAC-1100
      REAL*8 T
C
      COMMON/BLOCK1/PI,SQPI,SQRT2,A1B,A1C
      COMMON/CLOCK1/ET2,ET3,HCA,XCAT
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX
C
C
      SQT=SQRT(T)
      SQ1T=SQRT(1.-T)
```

```
      HC1=HCA/SQT                                                       PMT16250
      D33SQT=ET3*SQT                                                    PMT16260
C                                                                       PMT16270
      ARG1=HC1*HC1+XCAT*T                                               PMT16280
      CALL EXPO(-ARG1,EXP1)                                             PMT16290
      TERM1=EXP1/(SQT*SQ1T)                                             PMT16300
      IF(TERM1.LE.0.) GO TO 10                                          PMT16310
C                                                                       PMT16320
      ETA4=HC1+D33SQT                                                   PMT16330
      ETA4SQ=ETA4*ETA4                                                  PMT16340
      IF(ETA4SQ.GT.EXPMAX) CALL ARGCHK(ETA4,ETA4SQ)                     PMT16350
      TERM2=1.-SQPI*D33SQT*EXP(ETA4SQ)*ERFC(ETA4)                       PMT16360
      IF(TERM2.LE.0.) GO TO 10                                          PMT16370
C                                                                       PMT16380
      ETA5=ET2*SQ1T                                                     PMT16390
      ETA5SQ=ETA5*ETA5                                                  PMT16400
      IF(ETA5SQ.GT.EXPMAX) CALL ARGCHK(ETA5,ETA5SQ)                     PMT16410
      TERM3=1.-SQPI*ETA5*EXP(ETA5SQ)*ERFC(ETA5)                         PMT16420
      IF(TERM3.LE.0.) GO TO 10                                          PMT16430
C                                                                       PMT16440
      FUN1A=TERM1*TERM2*TERM3                                           PMT16450
      GO TO 20                                                          PMT16460
   10 FUN1A=0.                                                          PMT16470
   20 RETURN                                                            PMT16480
      END                                                               PMT16490
C
C                                                                       PMT16500
C                                                                       PMT16510
      DOUBLE PRECISION FUNCTION FUN2(T)                                 PMT16520
C                 REAL*8 FUNCTION FUN2 , PART OF PEM-2 (VERSION 84130). PMT16530
C                                                                       PMT16540
C                                                                       PMT16550
C     INTEGRAND FUNCTION USED IN THE NUMERICAL INTEGRATION FOR POINT    PMT16560
C     SOURCES (POLLUTANT SPECIES-2) IN SUBROUTINE PSG4P IS DEFINED HERE.PMT16570
C                                                                       PMT16580
C                                                                       PMT16590
C     PEM ALGORITHMS AND PROGRAM DEVELOPMENT: DECEMBER 1982             PMT16600
C     K. SHANKAR RAO                                                    PMT16610
C     NOAA-ATDL, P.O. BOX-E                                             PMT16620
C     OAK RIDGE, TENN 37830                                             PMT16630
C                                                                       PMT16640
C                                                                       PMT16650
C     FOR UNIVAC-1100                                                   PMT16660
      REAL*8 T                                                          PMT16670
C                                                                       PMT16680
      COMMON/PARM2/ISPEC,UTAUC,Q2Q1,XCT,EXCT                            PMT16690
      COMMON/PARM4/V11,V21,V12,V22,V13                                  PMT16700
      COMMON/PARM5/D11,D21,D12,D22,D31,D32,D33,D6                       PMT16710
      COMMON/PARM6/R11,R21,R12,R22,R13,R23,R31,R41,R32,R42              PMT16720
      COMMON/BLOCK1/PI,SQPI,SQRT2,A1B,A1C                               PMT16730
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX                                PMT16740
C                                                                       PMT16750
C                                                                       PMT16760
      SQT=SQRT(T)                                                       PMT16770
      SQ1T=SQRT(1.-T)                                                   PMT16780
      ETA4=D33*SQT                                                      PMT16790
      ETA5=D32*SQ1T                                                     PMT16800
      ETA6=D12*SQ1T                                                     PMT16810
      ETA6SQ=ETA6*ETA6                                                  PMT16820
      IF(ETA6SQ.GT.EXPMAX) CALL ARGCHK(ETA6,ETA6SQ)                     PMT16830
C                                                                       PMT16840
      ARG1=T*XCT                                                        PMT16850
      EXP1=EXP(-ARG1)                                                   PMT16860
      TERM1=EXP1/SQT                                                    PMT16870
C                                                                       PMT16880
      ETA4SQ=ETA4*ETA4                                                  PMT16890
      IF(ETA4SQ.GT.EXPMAX) CALL ARGCHK(ETA4,ETA4SQ)                     PMT16900
      TERM2=1.-SQPI*ETA4*(EXP(ETA4SQ)*ERFC(ETA4))                       PMT16910
      IF(TERM2.LE.0.) GO TO 15                                          PMT16920
C                                                                       PMT16930
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   11 IF(V22.EQ.0.) GO TO 12                                            PMT16940
      ETA5SQ=ETA5*ETA5                                                  PMT16950
      IF(ETA5SQ.GT.EXPMAX) CALL ARGCHK(ETA5,ETA5SQ)                     PMT16960
      T3A=EXP(ETA5SQ)*ERFC(ETA5)                                        PMT16970
      T3B=EXP(ETA6SQ)*ERFC(ETA6)                                        PMT16980
      TERM3=R12*T3A-R22*T3B                                             PMT16990
      IF(TERM3.LE.0.) GO TO 15                                          PMT17000
      GO TO 13                                                          PMT17010
C                                                                       PMT17020
   12 T3A=(1.+2.*ETA6SQ)*(EXP(ETA6SQ)*ERFC(ETA6))                       PMT17030
      T3B=2.*ETA6/SQPI                                                  PMT17040
      TERM3=T3A-T3B                                                     PMT17050
      IF(TERM3.LE.0.) GO TO 15                                          PMT17060
C                                                                       PMT17070
   13 FUN2=TERM1*TERM2*TERM3                                            PMT17080
      GO TO 16                                                          PMT17090
   15 FUN2=0.                                                           PMT17100
   16 RETURN                                                            PMT17110
      END                                                               PMT17120
C
C                                                                       PMT17130
C                                                                       PMT17140
      DOUBLE PRECISION FUNCTION FUN3(XA)                                PMT17150
C                 REAL*8 FUNCTION FUN3 , PART OF PEM-2 (VERSION 84130). PMT17160
C                                                                       PMT17170
C                                                                       PMT17180
C     INTEGRAND FUNCTION USED IN THE NUMERICAL INTEGRATION FOR AREA     PMT17190
C     SOURCES (POLLUTANT SPECIES-1) IN MAIN PROGRAM IS DEFINED HERE.    PMT17200
C                                                                       PMT17210
C                                                                       PMT17220
C     PEM-2 ALGORITHMS AND PROGRAM DEVELOPMENT: DECEMBER 1983           PMT17230
C     K. SHANKAR RAO                                                    PMT17240
C     NOAA-ATDL, P.O. BOX - E                                           PMT17250
C     OAK RIDGE, TENN 37830                                             PMT17260
C                                                                       PMT17270
C                                                                       PMT17280
C     FOR UNIVAC-1100                                                   PMT17290
      REAL*8 XA                                                         PMT17300
C                                                                       PMT17310
      COMMON/PARM1A/ICT,TAUC,GAMMA                                      PMT17320
      COMMON/PARM2/ISPEC,UTAUC,Q2Q1,XCT,EXCT                            PMT17330
      COMMON/PARM2A/HAS,KSC,AA,BA,CA                                    PMT17340
      COMMON/PARM3/HC,VDC1,WC1,VDC2,WC2                                 PMT17350
      COMMON/PARM4/V11,V21,V12,V22,V13                                  PMT17360
      COMMON/BLOCK1/PI,SQPI,SQRT2,A1B,A1C                               PMT17370
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX                                PMT17380
C                                                                       PMT17390
C                                                                       PMT17400
      SIGZ=AA*XA*(1.+CA*XA)/SQRT(1.+BA*XA)                              PMT17410
      C2=SQRT2*SIGZ                                                     PMT17420
      XCA=XA/C2                                                         PMT17430
      HCA=HAS/C2                                                        PMT17440
      D31=2.*V11*XCA                                                    PMT17450
C                                                                       PMT17460
      ETA1=HCA+D31                                                      PMT17470
      ETA1SQ=ETA1*ETA1                                                  PMT17480
      IF(ETA1SQ.GT.EXPMAX) CALL ARGCHK(ETA1,ETA1SQ)                     PMT17490
      TERM1=1.-SQPI*D31*EXP(ETA1SQ)*ERFC(ETA1)                          PMT17500
      IF(TERM1.LE.0.) GO TO 25                                          PMT17510
C                                                                       PMT17520
      BETA1=HCA-WC1*XCA                                                 PMT17530
      ARG1=BETA1*BETA1                                                  PMT17540
      IF(ISPEC.EQ.2) GO TO 20                                           PMT17550
      IF(ISPEC.EQ.1.AND.ICT.EQ.0) GO TO 20                              PMT17560
      IF(UTAUC.GT.0.) ARG1=ARG1+XA/UTAUC                                PMT17570
   20 CALL EXPO(-ARG1,EXP1)                                             PMT17580
C                                                                       PMT17590
      FUN3=EXP1*TERM1/SIGZ                                              PMT17600
      GO TO 30                                                          PMT17610
   25 FUN3=0.                                                           PMT17620
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   30 RETURN                                                            PMT17630
      END                                                               PMT17640
C
C                                                                       PMT17650
C                                                                       PMT17660
      DOUBLE PRECISION FUNCTION FUN4(XA)                                PMT17670
C                 REAL*8 FUNCTION FUN4 , PART OF PEM-2 (VERSION 84130). PMT17680
C                                                                       PMT17690
C                                                                       PMT17700
C     INTEGRAND FUNCTION USED IN THE NUMERICAL INTEGRATION FOR AREA     PMT17710
C     SOURCES (POLLUTANT SPECIES-2) IN THE MAIN PROGRAM IS DEFINED HERE.PMT17720
C     THIS FUNCTION CONSISTS ONLY OF THE CHEMICAL TRANSFORMATION        PMT17730
C     CONTRIBUTION TO THE SPECIES-2 CONCENTRATION BUDGET.               PMT17740
C                                                                       PMT17750
C                                                                       PMT17760
C     PEM-2 ALGORITHMS AND PROGRAM DEVELOPMENT: DECEMBER 1983           PMT17770
C     K. SHANKAR RAO                                                    PMT17780
C     NOAA-ATDL, P.O.BOX-E                                              PMT17790
C     OAK RIDGE, TENN 37830                                             PMT17800
C                                                                       PMT17810
C                                                                       PMT17820
      REAL*8 WORK(800),AI,BI,EPSABS,EPSREL,RESULT,ABSERR                PMT17830
      EXTERNAL FUN1A                                                    PMT17840
      REAL*8 FUN1A                                                      PMT17850
C     FOR UNIVAC-1100                                                   PMT17860
      REAL*8 XA                                                         PMT17870
C                                                                       PMT17880
      DIMENSION IW(102)                                                 PMT17890
      COMMON/PARM2/ISPEC,UTAUC,Q2Q1,XCT,EXCT                            PMT17900
      COMMON/PARM2A/HAS,KSC,AA,BA,CA                                    PMT17910
      COMMON/PARM3/HC,VDC1,WC1,VDC2,WC2                                 PMT17920
      COMMON/PARM4/V11,V21,V12,V22,V13                                  PMT17930
      COMMON/BLOCK1/PI,SQPI,SQRT2,A1B,A1C                               PMT17940
      COMMON/BLOCK2/AI,BI,EPSABS,EPSREL,LW,NIW                          PMT17950
      COMMON/CLOCK1/ET2,ET3,HCA,XCAT                                    PMT17960
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX                                PMT17970
C                                                                       PMT17980
      SIGZ=AA*XA*(1.+CA*XA)/SQRT(1.+BA*XA)                              PMT17990
      C2=SQRT2*SIGZ                                                     PMT18000
      XCA=XA/C2                                                         PMT18010
      HCA=HAS/C2                                                        PMT18020
      D32=2.*V12*XCA                                                    PMT18030
      D33=2.*V13*XCA                                                    PMT18040
C                                                                       PMT18050
      ETA2=HCA+D32                                                      PMT18060
      ETA2SQ=ETA2*ETA2                                                  PMT18070
      IF(ETA2SQ.GT.EXPMAX) CALL ARGCHK(ETA2,ETA2SQ)                     PMT18080
      TERM1=1.-SQPI*D32*EXP(ETA2SQ)*ERFC(ETA2)                          PMT18090
      IF(TERM1.LE.0.) GO TO 30                                          PMT18100
C                                                                       PMT18110
      ETA3=HCA+D33                                                      PMT18120
      ETA3SQ=ETA3*ETA3                                                  PMT18130
      IF(ETA3SQ.GT.EXPMAX) CALL ARGCHK(ETA3,ETA3SQ)                     PMT18140
      TERM2A=1.-SQPI*D33*EXP(ETA3SQ)*ERFC(ETA3)                         PMT18150
      IF(TERM2A.LE.0.) TERM2A=0.                                        PMT18160
      XCAT=XA/UTAUC                                                     PMT18170
      TERM2=EXP(-XCAT)*TERM2A                                           PMT18180
C                                                                       PMT18190
      IF(V21.EQ.V22) GO TO 20                                           PMT18200
      TERM3A=SQPI*2.*(V21-V22)*XCA                                      PMT18210
      ET2=D32                                                           PMT18220
      ET3=D33                                                           PMT18230
C     COMPUTE INTEGRAL F1A(AI,BI); FUN1A IS THE EXTERNALLY DEFINED      PMT18240
C     INTEGRAND FUNCTION.                                               PMT18250
      CALL D01AJF(FUN1A,AI,BI,EPSABS,EPSREL,RESULT,                     PMT18260
     1   ABSERR,WORK,LW,IW,NIW,IFAIL)                                   PMT18270
      TERM3=TERM3A*RESULT/PI                                            PMT18280
      GO TO 25                                                          PMT18290
   20 TERM3=0.                                                          PMT18300
C                                                                       PMT18310
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   25 BETA2=HCA-WC2*XCA                                                 PMT18320
      B2SQ=BETA2*BETA2                                                  PMT18330
      CALL EXPO(-B2SQ,EB2SQ)                                            PMT18340
      B3SQ=B2SQ-HCA*HCA                                                 PMT18350
      CALL EXPO(-B3SQ,EB3SQ)                                            PMT18360
      FUN4=(EB2SQ*(TERM1-TERM2)-EB3SQ*TERM3)/SIGZ                       PMT18370
      GO TO 35                                                          PMT18380
   30 FUN4=0.                                                           PMT18390
   35 RETURN                                                            PMT18400
      END                                                               PMT18410
C
C                                                                       PMT18420
C                                                                       PMT18430
      DOUBLE PRECISION FUNCTION FUN5(XA)                                PMT18440
C                 REAL*8 FUNCTION FUN5 , PART OF PEM-2 (VERSION 84130). PMT18450
C                                                                       PMT18460
C                                                                       PMT18470
C                                                                       PMT18480
C     INTEGRAND FUNCTION USED IN THE NUMERICAL INTEGRATION FOR AREA     PMT18490
C     SOURCES (POLLUTANT SPECIES-2) IN THE MAIN PROGRAM IS DEFINED HERE.PMT18500
C     THIS FUNCTION CONSISTS ONLY OF THE CONTRIBUTION OF THE DIRECT     PMT18510
C     EMISSION OF SPECIES-2 TO THE CONCENTRATION BUDGET.                PMT18520
C                                                                       PMT18530
C                                                                       PMT18540
C     PEM-2 ALGORITHMS AND PROGRAM DEVELOPMENT: FEBRUARY 1984           PMT18550
C     K. SHANKAR RAO                                                    PMT18560
C     NOAA-ATDL, P.O. BOX-E                                             PMT18570
C     OAK RIDGE, TENN 37830                                             PMT18580
C                                                                       PMT18590
C                                                                       PMT18600
C     FOR UNIVAC-1100                                                   PMT18610
        REAL*8 XA                                                       PMT18620
C                                                                       PMT18630
      COMMON/PARM2A/HAS,KSC,AA,BA,CA                                    PMT18640
      COMMON/PARM3/HC,VDC1,WC1,VDC2,WC2                                 PMT18650
      COMMON/PARM4/V11,V21,V12,V22,V13                                  PMT18660
      COMMON/BLOCK1/PI,SQPI,SQRT2,A1B,A1C                               PMT18670
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX                                PMT18680
C                                                                       PMT18690
      SIGZ=AA*XA*(1.+CA*XA)/SQRT(1.+BA*XA)                              PMT18700
      C2=SQRT2*SIGZ                                                     PMT18710
      XCA=XA/C2                                                         PMT18720
      HCA=HAS/C2                                                        PMT18730
      D32=2.*V12*XCA                                                    PMT18740
C                                                                       PMT18750
      ETA2=HCA+D32                                                      PMT18760
      ETA2SQ=ETA2*ETA2                                                  PMT18770
      IF(ETA2SQ.GT.EXPMAX) CALL ARGCHK(ETA2,ETA2SQ)                     PMT18780
      TERM1=1.-SQPI*D32*EXP(ETA2SQ)*ERFC(ETA2)                          PMT18790
      IF(TERM1.LE.0.) GO TO 10                                          PMT18800
C                                                                       PMT18810
      BETA2=HCA-WC2*XCA                                                 PMT18820
      B2SQ=BETA2*BETA2                                                  PMT18830
      CALL EXPO(-B2SQ,EB2SQ)                                            PMT18840
      FUN5=EB2SQ*TERM1/SIGZ                                             PMT18850
      GO TO 20                                                          PMT18860
   10 FUN5=0.                                                           PMT18870
   20 RETURN                                                            PMT18880
      END                                                               PMT18890
C
      SUBROUTINE EXPO(BX,EX)                                            PMT18920
C                                                                       PMT18900
C                                                                       PMT18910
C                     SUBROUTINE EXPO , PART OF PEM-2 (VERSION 84130). PMT18930
C                                                                       PMT18940
C                                                                       PMT18950
C     GIVEN THE ARGUMENT BX, SUBROUTINE EXPO CALCULATES AND             PMT18960
C     RETURNS EX=EXP(BX).  EXPO LIMITS THE ARGUMENT TO AVOID            PMT18970
C     OVERFLOW/UNDERFLOW ERRORS.                                        PMT18980
C                                                                       PMT18990
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C                                                                       PMT19000
C     PEM ALGORITHMS AND PROGRAM DEVELOPMENT: DECEMBER 1982             PMT19010
C     K. SHANKAR RAO                                                    PMT19020
C     NOAA-ATDL, P.O. BOX-E                                             PMT19030
C     OAK RIDGE, TENN 37831                                             PMT19040
C                                                                       PMT19050
C                                                                       PMT19060
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX                                PMT19070
C                                                                       PMT19080
C                                                                       PMT19090
      BXABS=ABS(BX)                                                     PMT19100
      IF(BX) 5,10,15                                                    PMT19110
    5 IF(BXABS-EXPMIN) 6,7,7                                            PMT19120
    6 EX=EXP(BX)                                                        PMT19130
      GO TO 20                                                          PMT19140
    7 EX=0.                                                             PMT19150
      GO TO 20                                                          PMT19160
   10 EX=1.                                                             PMT19170
      GO TO 20                                                          PMT19180
   15 IF(BXABS.GT.EXPMAX) BXABS=EXPMAX                                  PMT19190
      EX=EXP(BXABS)                                                     PMT19200
   20 RETURN                                                            PMT19210
      END                                                               PMT19220
C
C                                                                       PMT19230
C                                                                       PMT19240
      SUBROUTINE ARGCHK(E,ESQ)                                          PMT19250
C                     SUBROUTINE ARGCHK , PART OF PEM-2 (VERSION 84130). PMT19260
C                                                                       PMT19270
C                                                                       PMT19280
C     SUBROUTINE ARGCHK LIMITS THE ARGUMENTS OF EXP(ESQ)*ERFC(E)        PMT19290
C     TO AVOID OVERFLOW/UNDERFLOW ERRORS.                               PMT19300
C                                                                       PMT19310
C                                                                       PMT19320
C     PEM ALGORITHMS AND PROGRAM DEVELOPMENT:  DECEMBER 1982            PMT19330
C     K. SHANKAR RAO                                                    PMT19340
C     NOAA-ATDL, P.O. BOX-E                                             PMT19350
C     OAK RIDGE, TENN 37831                                             PMT19360
C                                                                       PMT19370
C                                                                       PMT19380
      COMMON/EXPCHK/EXPMAX,EXPMIN,ETAMAX                                PMT19390
C                                                                       PMT19400
C                                                                       PMT19410
      ESQ=EXPMAX                                                        PMT19420
      IF(E.LT.0.) NSIGN=-1                                              PMT19430
      IF(E.GE.0.) NSIGN=1                                               PMT19440
      E=NSIGN*ETAMAX                                                    PMT19450
      RETURN                                                            PMT19460
      END                                                               PMT19470
C
C                                                                       PMT19480
C                                                                       PMT19490
      SUBROUTINE INMOD                                                  PMT19500
C                     SUBROUTINE INMOD  , PART OF PEM-2 (VERSION 84130). PMT19510
C                                                                       PMT19520
C                                                                       PMT19530
C  SUBROUTINE INMOD READS IN ALL INPUTS TO THE MODEL, SCREENS THEM,     PMT19540
C    PRINTS WARNING MESSAGES, AND INSERTS DEFAULT VALUES AS NEEDED.     PMT19550
C    THE SUBROUTINE PRINTS OUT LISTS OF THE CONTROL PARAMETERS,         PMT19560
C    SCENARIO PARAMETERS, AND SOURCE DATA FOR REFERENCE.                PMT19570
C    INMOD ALSO PROCESSES THE INPUT FOR EACH SCENARIO BEFORE            PMT19580
C    TRANSMITTING IT TO THE MAIN PROGRAM.                               PMT19590
C                                                                       PMT19600
C                                                                       PMT19610
C *** PEM MODIFICATIONS AND FORMATS BY M.M. STEVENS,                    PMT19620
C     NOAA-ATDL, P.O. BOX-E, OAK RIDGE, TENN 37831                      PMT19630
C     DECEMBER 1982                                                     PMT19640
C *** PEM-2 MODIFICATIONS AND FORMATS BY K. SHANKAR RAO,                PMT19650
C     APRIL 1984                                                        PMT19660
C                                                                       PMT19670
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C
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),
     2 XA(50),YA(50),EA(50,2),SIZE(50),
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID
C
      COMMON/CSWOR/NWORST(25,25,5,2),CWORST(25,25,5,2)
      COMMON/PARM1/NPOL,VD1,W1,VD2,W2
      COMMON/PARM1A/ICT,TAUC,GAMMA
      COMMON/PARM2A/HAS,KSC,AA,BA,CA
      COMMON/PARM7A/HA,P1(6)
      COMMON/WND/HMIN,HMAX,UMIN,IUFLG
C
      DIMENSION NAME(2),WDINC(6),SUMAQ(2),SUMPQ(2),SUMAR(2),EAR(2),
     1 CWS(6)
      DIMENSION DCR(24,2),NSC(24),NWD(24),NWS(24),ASCALE(2)
      DIMENSION XX(100)
      DATA NAME/4H    ,4H    /
      DATA WDINC/1.5707963,0.7853982,0.5235988,0.2617994,
     1           0.1745329,0.08726646/
      DATA CWS/1.5,2.46,4.47,6.93,9.61,12.52/
      DATA HMIN/10./,HMAX/200./,UMIN/1./,HA/10./
C
      IF(INDEX.NE.0) GO TO 300
C
      ISTOP=0
C
C  R E A D   A L L   I N P U T   D A T A .
C
C **** READ FIRST CONTROL PARAMETER CARD (TITLE).
C
      READ(IRD,800)TT
      WRITE(IWR,900) TT
C
C **** READ SECOND CONTROL PARAMETER CARD (OPTIONS).
C
C    NTOPT  = AVERAGING TIME OPTION (1 OR 2 OR 3).
C    NWDOPT = WIND DIRECTION INPUT OPTION (0 TO 7).
C    NWSOPT = WIND SPEED INPUT OPTION (0 OR 1).
C    NWPOPT = WIND PROFILE EXPONENTS INPUT OPTION (0 OR 1).
C    NSCEN  = NUMBER OF SCENARIOS (1 TO 24).
C    NLIST  = OUTPUT OPTION: LISTS OF CONC AND SURF DEP FLUX (0 OR 1)
C    NARRAY = OUTPUT OPTION: MAPS OF CONC AND SURF DEP FLUX (0 TO 3)
C    NTAPE  = OUTPUT OPTION: TAPE OF CONC AND SURF DEP FLUX (0 OR 1)
C    NCSOPT = OUTPUT OPTION: POINT SOURCE CULPABILITY LIST (0 OR 1).
C    NMAX   = OUTPUT OPTION: MAXIMUM CONC. FOR EACH SCENARIO (0 OR 1).
C    NSTDWN = STACK-TIP DOWNWASH CORRECTION OPTION (0 OR 1).
C    NPRISE = NEW PLUME RISE EQUATIONS OPTION (0 OR 1).
C    NINPEN = NEW PLUME PENETRATION METHODS OPTION (0 OR 1).
C    INTER  = RECEPTOR INTERVAL ON TAPE OUTPUT (1,2,---).
C    NPRINT = OUTPUT OPTION: POINT SOURCE PLUME RISE INFO (0 OR 1)
C    INPTSC = INPUT OPTN: POINT SOURCE DATA ON UNIT IRD OR IDSK (1 OR 2)
C    NGPR = GRADUAL PLUME RISE OPTION NEAR PT. SOURCE (= 0),
C    NGPR = 1, THEN FINAL EFFECTIVE PLUME RISE AT ALL DISTANCES
C    NBID = BOUYANCY INDUCED DISPERSION (BID), (=0 NO BID, =1 YES)
C
      READ(IRD,805)NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,
     1 NTAPE,NCSOPT,NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,INPTSC,NGPR,
     1 NBID
C
      IF(NTOPT.GE.1 .AND  NTOPT.LE.3) GO TO 2
      WRITE(IWR,660) NTOPT
      NTOPT=1
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    2 IF(NWDOPT.LE.1) GO TO 6                                          PMT20320
      IF(NWDOPT.GT.7) GO TO 5                                          PMT20330
      IF(NTOPT.EQ.1 .OR. NWDOPT.LE.1) GO TO 6                          PMT20340
      WRITE(IWR,615)                                                   PMT20350
    5 NWDOPT=0                                                         PMT20360
    6 IF(NWSOPT.GT.1) NWSOPT=0                                         PMT20370
      IF(NWPOPT.GT.1) NWPOPT=0                                         PMT20380
      IF(NSCEN.EQ.0) NSCEN=1                                           PMT20390
      IF(NTOPT.EQ.3.AND.NSCEN.EQ.24) NTOPT=2                           PMT20400
      IF(NTOPT.EQ.2 .AND. NSCEN.NE.24) GO TO 500                       PMT20410
   10 IF(NSCEN.GT.24) GO TO 510                                        PMT20420
   20 IF(NLIST.EQ.0) GO TO 25                                          PMT20430
      IF(NLIST.GT.1) GO TO 22                                          PMT20440
      IF(NWDOPT.LE.1) GO TO 25                                         PMT20450
      WRITE(IWR,605)                                                   PMT20460
   22 NLIST=0                                                          PMT20470
   25 IF(NARRAY.GT.3) NARRAY=0                                         PMT20480
      IF(NTAPE.EQ.0) GO TO 40                                          PMT20490
      IF(NTAPE.GT.1) GO TO 30                                          PMT20500
      IF(NWDOPT.LE.1) GO TO 40                                         PMT20510
      WRITE(IWR,620)                                                   PMT20520
   30 NTAPE=0                                                          PMT20530
   40 IF(NCSOPT.EQ.0) GO TO 51                                         PMT20540
      IF(NCSOPT.GT.1) NCSOPT=0                                         PMT20550
      IF(NTOPT.EQ.1) GO TO 45                                          PMT20560
      NCSOPT=0                                                         PMT20570
      WRITE(IWR,625)                                                   PMT20580
   45 IF(NWDOPT.GT.1.AND.NSCEN.GT.1) GO TO 50                          PMT20590
      GO TO 51                                                         PMT20600
   50 NCSOPT=0                                                         PMT20610
      WRITE(IWR,635)                                                   PMT20620
   51 IF(NMAX.GT.1) NMAX=0                                             PMT20630
      IF(NSTDWN.GT.1) NSTDWN=0                                         PMT20640
      IF(NPRISE.GT.1) NPRISE=0                                         PMT20650
      IF(NINPEN.GT.1) NINPEN=0                                         PMT20660
      IF(INTER.EQ.0) INTER=1                                           PMT20670
      IF(NPRINT.GT.1) NPRINT=0                                         PMT20680
      IF(INPTSC.LT.1 .OR. INPTSC.GT.2) INPTSC=1                        PMT20690
C                                                                      PMT20700
C      SET LABEL FOR TIME AVERAGING                                    PMT20710
      IAV=1                                                            PMT20720
      IF(NTOPT.EQ.2) IAV=24                                            PMT20730
      IF (NTOPT.EQ.3) IAV=NSCEN                                        PMT20740
C                                                                      PMT20750
C  **** READ THIRD CONTROL PARAMETER CARD (GRID, DTDZ)                 PMT20760
C                                                                      PMT20770
C    XRSWC,YRSWC = COORDINATES OF SOUTHWEST CORNER OF RECEPTOR GRID (KM)PMT20780
C    LX          = NUMBER OF COLUMNS IN RECEPTOR GRID.                 PMT20790
C    LY          = NUMBER OF ROWS IN RECEPTOR GRID.                    PMT20800
C    GRID        = SPACING BETWEEN ROWS AND COLUMNS OF RECEPTOR GRID (KM) PMT20810
C                                                                      PMT20820
C    DTDZ(1&2) = VERTICAL POTENTIAL TEMPERATURE GRADIENT               PMT20830
C                  FOR STABILITY CLASSES E & F.                        PMT20840
C                                                                      PMT20850
      READ(IRD,810)XRSWC,YRSWC,LX,LY,GRID,DTDZ(1),DTDZ(2)              PMT20860
C                                                                      PMT20870
      IF(LX.EQ.0) LX=1                                                 PMT20880
      IF(LY.EQ.0) LY=1                                                 PMT20890
      IF(NTAPE.EQ.0) GO TO 115                                         PMT20900
C                                                                      PMT20910
      NRECS=((LX+1)/INTER)*((LY+1)/INTER)*NSCEN                        PMT20920
      IF(NTOPT.EQ.2) NRECS= NRECS/24                                   PMT20930
      IF(NTOPT.EQ.3) NRECS= NRECS/NSCEN                                PMT20940
      IF(NRECS.LT.62500) GO TO 115                                     PMT20950
      WRITE(IWR,600)                                                   PMT20960
      NTAPE=0                                                          PMT20970
115   CONTINUE                                                         PMT20980
C                                                                      PMT20990
C  **** READ FOURTH CONTROL PARAMETER CARD (POLLUTANTS)                PMT21000
C                                                                      PMT21010
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C     NPOL  = NUMBER OF POLLUTANTS (1 OR 2)                                PMT21020
C     ICT   = CHEMICAL TRANSFORMATION OR DECAY OPTION (0 OR 1)             PMT21030
C     VD1   = DEPOSITION VELOCITY FOR POLLUTANT SPECIES-1 (CM/S)           PMT21040
C     W1    = SETTLING VELOCITY FOR POLLUTANT SPOECIES-1 (CM/S)            PMT21050
C     VD2   = DEPOSITION VELOCITY FOR POLLUTANT SPECIES-2 (CM/S)           PMT21060
C     W2    = SETTLING VELOCITY FOR POLLUTANT SPECIES-2 (CM/S)             PMT21070
C     XKT   = CHEMICAL TRANSFORMATION OR DECAY RATE OF POLLUTANT           PMT21080
C               SPECIES-1 (PERCENT PER HOUR)                               PMT21090
C     GAMMA = RATIO OF MOLECULAR WEIGHTS OF SPECIES-2 (PRODUCT)            PMT21100
C               TO SPECIES-1 (REACTANT) IN CHEMICAL TRANSFORMATION         PMT21110
C                                                                          PMT21120
C  NOTE: FOR DEPOSITION TO OCCUR, W SHOULD BE LESS THAN OR EQUAL TO VD.    PMT21130
C        FOR DEPOSITION OF GASES AND VERY SMALL PARTICLES, W=0.            PMT21140
C        FOR DEPOSITION OF SMALL PARTICLES, W IS LESS THAN VD.             PMT21150
C        FOR DEPOSITION OF PARTICLES OF SIZE > 50 MICRONS, W=VD.           PMT21160
C                                                                          PMT21170
      READ (IRD,812) NPOL,ICT,VD1,W1,VD2,W2,XKT,GAMMA                      PMT21180
C                                                                          PMT21190
      IF(NPOL.LT.1 .OR. NPOL.GT.2) NPOL=1                                  PMT21200
      IF(W1.GT.VD1) W1=VD1                                                 PMT21210
      IF(W1.LT.0.01) W1=0.0                                                PMT21220
      IF(VD1.LT.0.01) VD1=0.0                                              PMT21230
      IF(NPOL.EQ.2) GO TO 117                                              PMT21240
      VD2=0.0                                                              PMT21250
      W2=0.0                                                               PMT21260
      GO TO 118                                                            PMT21270
  117 IF(W2.GT.VD2) W2=VD2                                                 PMT21280
      IF(W2.LT.0.01) W2=0.0                                                PMT21290
      IF(VD2.LT.0.01) VD2=0.0                                              PMT21300
  118 IF(ICT.EQ.1) GO TO 119                                               PMT21310
      XKT=0.0                                                              PMT21320
      GAMMA=0.0                                                            PMT21330
      GO TO 122                                                            PMT21340
  119 IF(XKT.GE.0.1 .AND. XKT.LE.100.) GO TO 120                           PMT21350
      TXKT=0.1                                                             PMT21360
      IF(XKT.GT.100.) TXKT=100.                                            PMT21370
      WRITE(IWR,640) XKT,TXKT                                              PMT21380
      XKT=TXKT                                                             PMT21390
C                                                                          PMT21400
C    CONVERT CHEMICAL TRANSFORMATION RATE XKT (PERCENT PER HOUR) TO        PMT21410
C     THE EQUIVALENT TIME SCALE TAUC (SECONDS).                            PMT21420
  120 TAUC=0.36E06/XKT                                                     PMT21430
C                                                                          PMT21440
  122 IF(NCSOPT.EQ.0 .OR. (LX.LE.25 .AND. LY.LE.25)) GO TO 125             PMT21450
      WRITE(IWR,645)                                                       PMT21460
      NCSOPT=0                                                             PMT21470
C                                                                          PMT21480
C     SHIFT THE RECEPTOR GRID TO THE COMPUTATION GRID.                     PMT21490
125   XSWC= XRSWC - 0.5*GRID                                               PMT21500
      YSWC= YRSWC - 0.5*GRID                                               PMT21510
C                                                                          PMT21520
130   IF(DTDZ(1).LT.0.00001) DTDZ(1)=0.020                                 PMT21530
      IF(DTDZ(2).LT.0.00001) DTDZ(2)=0.035                                 PMT21540
C                                                                          PMT21550
C  IF GRID IS ZERO, SWITCH ON AUTOMATIC GRID OPTION.                       PMT21560
      IGRID=0                                                              PMT21570
      IF(GRID.LT.1.0E-5) IGRID=1                                           PMT21580
      IF(IGRID.EQ.1.AND.NTOPT.GT.1) GO TO 520                              PMT21590
C                                                                          PMT21600
C **** READ 5TH CONTROL PARAMETER CARD (AREA SOURCE EMISSIONS HEIGHT       PMT21610
C                          AND SCALING  , AND CONCENTRATION CALIBRATION)   PMT21620
C                                                                          PMT21630
C    HAS          = EFFECTIVE HEIGHT OF AREA SOURCE EMISSIONS (METERS).   PMT21640
C    ASCALE(1&2)  = AREA SOURCE EMISSION SCALING FACTORS                  PMT21650
C                     FOR POLLUTANT SPECIES-1 AND 2.                      PMT21660
C    A(1&2)       = CONCENTRATION CALIBRATION FACTOR (INTERCEPT)          PMT21670
C                     FOR POLLUTANT SPECIES-1 AND 2.                      PMT21680
C    B(1&2)       = CONCENTRATION CALIBRATION FACTOR (SLOPE)              PMT21690
C                     FOR POLLUTANT SPECIES-1 AND 2.                      PMT21700
C                                                                          PMT21710
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  135 READ(IRD,815) HAS,ASCALE(1),ASCALE(2),A(1),B(1),A(2),B(2)
C
      IF(ASCALE(1).LE.0.) ASCALE(1)=1.0
      IF(ASCALE(2).LE.0.) ASCALE(2)=1.0
C
C  **** READ CARD 6 (POLLUTANT AND CALIBRATION LABELS)
C
      READ(IRD,817)(POLNAM(I,1),I=1,3),(CALNAM(I,1),I=1,7),
     1             (POLNAM(I,2),I=1,3),(CALNAM(I,2),I=1,7)
C
      IF(NWPOPT.EQ.0) GO TO 136
C  **** READ CARD 7 (WIND PROFILE EXPONENTS AND ANEMOMETER HEIGHT)
C  NOTE: THIS IS AN OPTIONAL CARD
C
C    HA          = ANEMOMETER HEIGHT (METERS)
C    P1(I),I=1,6 = WIND PROFILE EXPONENTS FOR STABILITY CLASSES 1 TO 6
C    HMIN        = WIND CONSTANT BELOW THIS HEIGHT (DEFAULT 10 M)
C    HMAX        = WIND CONSTANT ABOVE THIS HEIGHT (DEFAULT 200M)
C    UMIN  = WIND SPEED NOT ALLOWED LESS THEN THIS VALUE (DEFAULT 1 M/S)
      READ(IRD,818) HA, HMIN, HMAX, UMIN,(P1(I),I=1,6)
C     CHECK FOR DEFAULTS AND SET THEM EQUAL TO STANDARD VALUES.
      IF(HA.LT.0.01) HA=10.
      IF(HMIN.LT.0.01) HMIN=10.
      IF(HMAX.LT.0.01) HMAX=200.
      IF(UMIN.LT.0.01) UMIN=1.
      DO 136 I=1,6
      IF(P1(I).LT.0.01) P1(I)=P(I)
  136 CONTINUE
C
C  **** READ ONE TO 24 SCENARIO PARAMETER CARDS.
C
C    NSC       = STABILITY CLASS NUMBER (1 TO 6)
C    NWS       = WIND SPEED CLASS NUMBER (1 TO 6)
C    NWD       = WIND SECTOR NUMBER (1 TO 16)
C    WS        = WIND SPEED (M/S)
C    WD        = WIND DIRECTION (DEGREES)
C    TA        = AMBIENT TEMPERATURE (DEGREES CELSIUS)
C    HMIX      = MIXING HEIGHT (METERS)
C    DTDZI     = POT.TEMP.GRADIENT IN ELEVATED STABLE LAYER (DEG.C/M)
C
      DO 150 IS=1,NSCEN
      READ(IRD,820)NSC(IS),NWS(IS),NWD(IS),WS(IS),WD(IS),TA(IS),
     1 HMIX(IS),DTDZI(IS)
C
      IF(NSC(IS).GE.1 .AND. NSC(IS).LE.6) GO TO 140
      NUM=1
      IF(NSC(IS).GT.6) NUM=6
      WRITE(IWR,535) IS,NSC(IS),NUM
      NSC(IS)=NUM
  140 IF(NWSOPT.EQ.0) GO TO 142
      IF(NWS(IS).GE.1 .AND. NWS(IS).LE.6) GO TO 144
      NUM=1
      IF(NWS(IS).GT.6) NUM=6
      WRITE(IWR,545) IS,NWS(IS),NUM
      NWS(IS)=NUM
      GO TO 144
  142 IF(WS(IS).GT.0.) GO TO 144
      WRITE(IWR,565) IS,WS(IS)
      WS(IS)=1.0
  144 IF(NWDOPT.NE.1) GO TO 146
      IF(NWD(IS).GE.1 .AND. NWD(IS).LE.16) GO TO 146
      NUM=1
      IF(NWD(IS).GT.16) NUM=16
      WRITE(IWR,555) IS,NWD(IS),NUM
      NWD(IS)=NUM
  146 IF(HMIX(IS).LT.1.0E-5) HMIX(IS)= 9999.9
      IF(NINPEN.EQ.0) GO TO 150
      IF(DTDZI(IS).LT.0.00001) DTDZI(IS)=0.010
150   CONTINUE
C
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C  PRINT INPUT CONTROL PARAMETERS                                      PMT22360
C                                                                       PMT22370
      IF(ISTOP.EQ.1) WRITE(IWR,900) TT                                  PMT22380
      WRITE(IWR,902) NTOPT                                              PMT22390
      WRITE(IWR,904) NWDOPT                                             PMT22400
      WRITE(IWR,906) NWSOPT                                             PMT22410
      WRITE(IWR,908) NSCEN                                              PMT22420
      IF(IGRID.EQ.0) WRITE(IWR,916) LX,LY,GRID,XRSWC,YRSWC              PMT22430
      WRITE(IWR,900) TT                                                 PMT22440
      WRITE(IWR,922) NPOL,(POLNAM(I,1),I=1,3)                           PMT22450
      IF(NPOL.EQ.2) WRITE(IWR,923) (POLNAM(I,2),I=1,3)                  PMT22460
      WRITE(IWR,924) ASCALE(1)                                          PMT22470
      IF(NPOL.EQ.2) WRITE(IWR,935) ASCALE(2)                            PMT22480
      WRITE(IWR,925) A(1),B(1)                                          PMT22490
      IF(NPOL.EQ.2) WRITE(IWR,926) A(2),B(2)                            PMT22500
      WRITE(IWR,927) (CALNAM(I,1),I=1,7)                                PMT22510
      IF(NPOL.EQ.2) WRITE(IWR,921) (CALNAM(I,2),I=1,7)                  PMT22520
      WRITE(IWR,928) VD1                                                PMT22530
      IF(NPOL.EQ.2) WRITE(IWR,931) VD2                                  PMT22540
      WRITE(IWR,929) W1                                                 PMT22550
      IF(NPOL.EQ.2) WRITE(IWR,933) W2                                   PMT22560
      WRITE(IWR,930) ICT                                                PMT22570
      IF(NPOL.EQ.1) WRITE(IWR,932)                                      PMT22580
      IF(NPOL.EQ.2) WRITE(IWR,934)                                      PMT22590
      IF(ICT.EQ.0) GO TO 152                                            PMT22600
      WRITE(IWR,936) XKT                                                PMT22610
      IF(NPOL.EQ.1) GO TO 152                                           PMT22620
      WRITE(IWR,938) GAMMA                                              PMT22630
  152 WRITE(IWR,940)                                                    PMT22640
      IF(NLIST.GT.0) WRITE(IWR,942) NLIST                               PMT22650
      IF(NARRAY.GT.0) WRITE(IWR,944) NARRAY                             PMT22660
      IF(NARRAY.EQ.1) WRITE(IWR,946)                                    PMT22670
      IF(NARRAY.EQ.2) WRITE(IWR,948)                                    PMT22680
      IF(NARRAY.EQ.3) WRITE(IWR,950)                                    PMT22690
      IF(NTAPE.GT.0) WRITE(IWR,952) NTAPE,INTER                         PMT22700
      IF(NMAX.GT.0) WRITE(IWR,958) NMAX                                 PMT22710
C                                                                       PMT22720
C    PRINT INPUT PARAMETERS FOR SCENARIOS                               PMT22730
C                                                                       PMT22740
      WRITE(IWR,960)TT                                                  PMT22750
      WRITE(IWR,962)                                                    PMT22760
      WRITE(IWR,963)                                                    PMT22770
      WRITE(IWR,964)                                                    PMT22780
C                                                                       PMT22790
      DO 162 IS=1,NSCEN                                                 PMT22800
      KS=NSC(IS)                                                        PMT22810
      WRITE(IWR,966) IS,SCLAB(KS)                                       PMT22820
      IF(NWSOPT.EQ.0) GO TO 153                                         PMT22830
      KW=NWS(IS)                                                        PMT22840
      WS(IS)=CWS(KW)                                                    PMT22850
      WRITE(IWR,970) KW                                                 PMT22860
      GO TO 154                                                         PMT22870
  153 WRITE(IWR,972) WS(IS)                                             PMT22880
  154 IF(NWDOPT.EQ.1) GO TO 155                                         PMT22890
      WDOUT=WD(IS)                                                      PMT22900
      WRITE(IWR,973) WDOUT                                              PMT22910
      GO TO 156                                                         PMT22920
  155 KD=NWD(IS)                                                        PMT22930
      WDOUT=SECTAN(KD) * 180./3.14159265                                PMT22940
      WRITE(IWR,974) KD                                                 PMT22950
  156 IF(NINPEN.EQ.1)WRITE(IWR,978)TA(IS),DTDZI(IS),HMIX(IS)            PMT22960
      IF(NINPEN.EQ.0)WRITE(IWR,979) TA(IS),HMIX(IS)                     PMT22970
      WD(IS)= WD(IS)*3.14159265/180.                                    PMT22980
      TA(IS)= TA(IS) + 273.15                                           PMT22990
C                                                                       PMT23000
C  FOR EACH SCENARIO, CALCULATE THE CRITICAL DOWNWIND DISTANCES         PMT23010
C    AT WHICH VERTICAL MIXING IMPENDS (DCRIT(IS,1)) AND IS COMPLETE     PMT23020
C    (DCRIT(IS,2)).                                                     PMT23030
      JSC=NSC(IS)                                                       PMT23040
      PC1=0.47*HMIX(IS)/AZ(JSC)                                         PMT23050
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      IF(JSC.NE.3) GO TO 157
C
C  STABILITY CLASS C
      DCR(IS,1)=.001*PC1
      GO TO 161
  157 IF(JSC.LT.3) GO TO 158
C
C  STABILITY CLASSES D,E, AND F
      PC2=PC1*PC1*BZ(JSC)
      PC3=2./(PC1*BZ(JSC))
      DUMMY= 0.5*PC2*(1.+SQRT(1.+PC3*PC3))
      DCR(IS,1)=.001*DUMMY
      GO TO 161
C
C  STABILITY CLASSES A AND B
C  FIRST APPROXIMATION
  158 XX(1)=PC1
      DO 159 I=1,100
      I1=I+1
      XX(I1)=PC1/SQRT(1.+BZ(JSC)*XX(I))
      DIFF=ABS(XX(I1)-XX(I))
      IF(DIFF.LE.0.5) GO TO 160
  159 CONTINUE
  160 DCR(IS,1)=.001*XX(I1)
  161 DCR(IS,2)=2.*DCR(IS,1)
162   CONTINUE
C
C  **** READ UP TO 50 AREA SOURCE CARDS.
C
C    XA,YA   = COORDINATES OF SOUTHWEST CORNER OF AREA SOURCE (KM).
C    SIZE    = LENGTH OF A SIDE OF AREA SOURCE (M).
C    EA(1&2) = EMISSION RATES OF 2 POLLUTANTS (G/S).
C     NOTE THAT EA(1&2) ARE EMISSION RATES OF AN EQUIVALENT POINT
C     SOURCE LOCATED AT THE CENTER OF THE AREA SOURCE.
C
      WRITE(IWR,990) TT
      NAS=1
      SUMAQ(1)=0.
      SUMAQ(2)=0.
      SUMAR(1)=0.
      SUMAR(2)=0.
C
170   READ(IRD,825)XA(NAS),YA(NAS),SIZE(NAS),EA(NAS,1),EA(NAS,2)
C
      IF(NPOL.EQ.1) EA(NAS,2)=0.0
      IF((SIZE(NAS)+EA(NAS,1)+EA(NAS,2)).LT.1.0E-04) GO TO 180
      IF(SIZE(NAS).GE.1.0) GO TO 172
      SIZE(NAS)=1.0
      IF(GRID.NE.0.) SIZE(NAS)=GRID*1000.
      WRITE(IWR,585) NAS,SIZE(NAS)
  172 DO 175 K=1,2
      EAR(K)=EA(NAS,K)
      SUMAR(K)=SUMAR(K)+EAR(K)
      EA(NAS,K)= EA(NAS,K)*ASCALE(K)
175   SUMAQ(K)=SUMAQ(K)+EA(NAS,K)
C
C   PRINT INPUT PARAMETERS FOR THIS AREA SOURCE
      WRITE(IWR,992)NAS,XA(NAS),YA(NAS),SIZE(NAS),EAR(1),EA(NAS,1),
     1EAR(2),EA(NAS,2)
C
      SIZE(NAS)=SIZE(NAS)*0.001
      IF(NAS/50*50.EQ.NAS) WRITE(IWR,990)TT
      NAS=NAS+1
      GO TO 170
180   NAS=NAS-1
      WRITE(IWR,994) SUMAR(1),SUMAQ(1),SUMAR(2),SUMAQ(2)
      WRITE(IWR,996) HAS
C
C
C  **** READ UP TO 300 POINT SOURCES
```

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C                                                                       PMT23760
C     XP,YP    = COORDINATES OF POINT SOURCE (KM).                      PMT23770
C     EP(1&2)  = EMISSION RATES OF 2 POLLUTANTS (G/S).                  PMT23780
C     HP       = SOURCE HEIGHT (M).                                     PMT23790
C     DP       = INSIDE DIAMETER (M).                                   PMT23800
C     VP       = VELOCITY (M/S).                                        PMT23810
C     TP       = TEMPERATURE (DEGREES CELSIUS).                         PMT23820
C     NAME     = IDENTIFICATION.                                        PMT23830
C                                                                       PMT23840
  184 WRITE(IWR,980) TT                                                 PMT23850
      NPS=1                                                             PMT23860
      SUMPQ(1)=0.                                                       PMT23870
      SUMPQ(2)=0.                                                       PMT23880
C                                                                       PMT23890
  185 IF(INPTSC.EQ.2)READ(IDSK,830)XP(NPS),YP(NPS),EP(NPS,1),EP(NPS,2), PMT23900
     1 HP(NPS),DP(NPS),VP(NPS),TP(NPS),NAME(1),NAME(2)                  PMT23910
      IF(INPTSC.EQ.1) READ(IRD,830)XP(NPS),YP(NPS),EP(NPS,1),EP(NPS,2), PMT23920
     1 HP(NPS),DP(NPS),VP(NPS),TP(NPS),NAME(1),NAME(2)                  PMT23930
C                                                                       PMT23940
      IF(NPOL.EQ.1) EP(NPS,2)=0.0                                       PMT23950
      IF(HP(NPS)+DP(NPS)+VP(NPS)+TP(NPS).LT.1.0E-4) GO TO 190           PMT23960
      IF(DP(NPS).GT.0.0) GO TO 187                                      PMT23970
      WRITE(IWR,575) NPS                                                PMT23980
      DP(NPS)=1.0E-4                                                    PMT23990
C                                                                       PMT24000
C  PRINT INPUT PARAMETERS FOR THIS POINT SOURCE                         PMT24010
  187 WRITE(IWR,984) NPS,NAME(1),NAME(2),XP(NPS),YP(NPS),EP(NPS,1),     PMT24020
     1 EP(NPS,2),HP(NPS),DP(NPS),VP(NPS),TP(NPS)                        PMT24030
C                                                                       PMT24040
      TP(NPS)=TP(NPS)+273.15                                            PMT24050
      IF(NPS/50*50.EQ.NPS) WRITE(IWR,980)TT                             PMT24060
      SUMPQ(1)=SUMPQ(1)+EP(NPS,1)                                       PMT24070
      SUMPQ(2)=SUMPQ(2)+EP(NPS,2)                                       PMT24080
      NPS=NPS+1                                                         PMT24090
      GO TO 185                                                         PMT24100
190   NPS= NPS-1                                                        PMT24110
      WRITE(IWR,986) SUMPQ(1),SUMPQ(2)                                  PMT24120
C                                                                       PMT24130
      IF(NPS.LT.1) GO TO 192                                            PMT24140
      WRITE(IWR,901)                                                    PMT24150
      WRITE(IWR,907) NWPOPT                                             PMT24160
      IF(NWPOPT.EQ.1) WRITE(IWR,959) (P1(I),I=1,6),HA ,HMIN,HMAX,UMIN   PMT24170
      WRITE(IWR,910) NSTDWN                                             PMT24180
      WRITE(IWR,911) NPRISE                                             PMT24190
      WRITE(IWR,920) DTDZ(1),DTDZ(2)                                    PMT24200
      WRITE(IWR,912) NINPEN                                             PMT24210
      IF(IGRID.EQ.1) WRITE(IWR,914)                                     PMT24220
      IF(NCSOPT.GT.0.OR.NPRINT.GT.0) WRITE(IWR,940)                     PMT24230
      IF(NCSOPT.GT.0) WRITE(IWR,954) NCSOPT                             PMT24240
      IF(NPRINT.GT.0) WRITE(IWR,956) NPRINT                             PMT24250
      IF(NGPR.EQ.0) WRITE(IWR,915) NGPR                                 PMT24251
      IF(NGPR.EQ.1) WRITE(IWR,919) NGPR                                 PMT24252
915   FORMAT(' ',10X,'GRAD. PLUME RISE OPTION WHEN NGPR=0 : NGPR = ',I1)PMT24253
919   FORMAT(' ',10X,' FINAL EFFECTIVE PLUME RISE USED: NGPR =',I1)     PMT24254
      WRITE(IWR,918) NBID                                               PMT24255
918   FORMAT(' ',9X,'BOUYANCY INDUCED DISPERSION FOR NBID=1: NBID=',I2) PMT24256
C                                                                       PMT24260
C    IF THERE WERE SERIOUS ERRORS IN INPUT PARAMETERS, STOP             PMT24270
  192 IF(ISTOP.EQ.0) GO TO 195                                          PMT24280
      WRITE(IWR,630)                                                    PMT24290
      CALL WAUDIT
      STOP                                                              PMT24300
C                                                                       PMT24310
C   INITIALIZE FOR FIRST CALL TO INMOD FOR SCENARIO PREPARATION         PMT24320
  195 IWDOPT= 0                                                         PMT24330
      ISCEN=0                                                           PMT24340
      RETURN                                                            PMT24350
C                                                                       PMT24360
C                                                                       PMT24370
C  P R E P A R E   S C E N A R I O   I N F O R M A T I O N .            PMT24380
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C
300   IF(NWDOPT.LE.1) GO TO 350
      IF(ISCEN.EQ.0.OR.IWDOPT.GE.4) GO TO 320
      IWDOPT= IWDOPT + 1
      WD(ISCEN)= WD(ISCEN) + WDINC(NWDOPT-1)
      IF(WD(ISCEN).GE.6.2831853) WD(ISCEN)=WD(ISCEN) - 6.2831853
      GO TO 353
320   ISCEN= ISCEN + 1
      IWDOPT= 1
      GO TO 353
350   ISCEN= ISCEN + 1
353   ISC=NSC(ISCEN)
      IWD=NWD(ISCEN)
      D47= DCR(ISCEN,1)
      D80= DCR(ISCEN,2)
      D8047= D80 - D47
      IF(NCSOPT.EQ.0) GO TO 400
      DO 380 I=1,25
      DO 380 J=1,25
      DO 380 K=1,5
      DO 380 N=1,2
      NWORST(I,J,K,N)=0
380   CWORST(I,J,K,N)=0.
400   RETURN
C
C   ERROR MESSAGES
C
  500 WRITE(IWR,505)
  505 FORMAT(1H0,'WHEN TIME AVG OPTION NTOPT=2, NUMBER OF SCENARIOS MUST
     1 =24')
      ISTOP=1
      GO TO 10
  510 WRITE(IWR,515) NSCEN
  515 FORMAT(1H0,'MAXIMUM NUMBER OF SCENARIOS ALLOWED IS 24. NSCEN=',I4)
      ISTOP=1
      GO TO 20
  520 WRITE(IWR,525)
  525 FORMAT(1H0,'AUTOGRID MAY NOT BE USED WITH TIME AVG OPTION NTOPT>1'
     1)
      ISTOP=1
      GO TO 135
  535 FORMAT(1H0,'IN SCENARIO',I3,' STABILITY CLASS NUMBER NSC=',I2,
     1' IS OUT OF RANGE.  NSC SET TO',I2)
  545 FORMAT(1H0,'IN SCENARIO',I3,' WIND SPEED CLASS NUMBER NWS=',I2,
     1' IS OUT OF RANGE.  NWS SET TO',I2)
  555 FORMAT(1H0,'IN SCENARIO',I3,' WIND DIRECTION SECTOR NUMBER NWD=',
     1 I3,' IS OUT OF RANGE.  NWD SET TO',I3)
  565 FORMAT(1H0,'IN SCENARIO',I3,' SPECIFIED WIND SPEED WS =',F7.3,' IS
     1 LESS THAN ZERO.  WS SET TO 1.0 M/S')
  575 FORMAT(1H0,'POINT SOURCE',I4,':  INSIDE DIAMETER MUST BE GREATER T
     1HAN ZERO.  DP SET TO .0001 M')
  585 FORMAT(1H0,'AREA SOURCE',I3,':  LENGTH OF SIDE MUST BE GREATER THA
     1N ZERO.  SIZE SET TO ',F9.2)
  600 FORMAT(1H0,'RUN REQUESTED WOULD PRODUCE OVER 62500 RECORDS ON TAPE
     1'/' OUTPUT OPTION NTAPE HAS BEEN SET TO ZERO')
  605 FORMAT(1H0,'OUTPUT OPTION NLIST MAY NOT BE USED WITH AUTOMATIC WIN
     1D SHIFT OPTION (NWDOPT>1)'/' NLIST HAS BEEN SET TO ZERO')
  615 FORMAT(1H0,'AUTOMATIC WIND SHIFT OPTION (NWDOPT>1) MAY NOT BE USED
     1 WITH TIME AVG OPTION NTOPT>1'/' NWDOPT HAS BEEN SET TO ZERO')
  620 FORMAT(1H0,'OUTPUT OPTION NTAPE MAY NOT BE USED WITH AUTOMATIC WIN
     1D SHIFT OPTION (NWDOPT>1)'/' NTAPE HAS BEEN SET TO ZERO')
  625 FORMAT(1H0,'CONTROL STRATEGY OUTPUT OPTION NCSOPT MAY NOT BE USED
     1WITH NTOPT>1'/' NCSOPT HAS BEEN SET TO ZERO')
  630 FORMAT(1H1//' SERIOUS ERROR(S) IN INPUT PARAMETERS',5X,
     1 'RUN CANNOT BE CONTINUED')
  635 FORMAT(1H0,'CONTROL STRATEGY OUTPUT OPTION NCSOPT MAY NOT BE USED
     1FOR MORE THAN'/' ONE SCENARIO WITH AUTOMATIC WINDSHIFT OPTION'/,
     2' NCSOPT HAS BEEN SET TO ZERO')
  640 FORMAT(1H0,'CHEMICAL TRANSFORMATION RATE XKT=',F7.3,' IS OUT OF RA
     1NGE'/' XKT HAS BEEN SET TO',F8.3)
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  645 FORMAT(1H0,'CONTROL STRATEGY OUTPUT OPTION NCSOPT MAY NOT BE USED PMT25090
     1WHEN NUMBER OF COLUMNS OR ROWS IN RECEPTOR GRID IS GREATER THAN 25PMT25100
     2'/' NCSOPT HAS BEEN SET TO ZERO')                                 PMT25110
  660 FORMAT(1H0,'TIME AVERAGING OPTION NTOPT=',I2,' IS OUT OF RANGE.  NPMT25120
     1TOPT SET TO 1')                                                   PMT25130
C                                                                       PMT25140
C   INPUT FORMATS                                                       PMT25150
C                                                                       PMT25160
800   FORMAT(20A4)                                                      PMT25170
805   FORMAT(18I4)                                                      PMT25180
810   FORMAT(2F10.0,2I10,3F10.0)                                        PMT25190
812   FORMAT(2I5,6F10.0)                                                PMT25200
815   FORMAT(7F10.0)                                                    PMT25210
817   FORMAT(3A4,7A4,3A4,7A4)                                           PMT25220
818   FORMAT(10F7.0)                                                    PMT25230
820   FORMAT(3I5,5F10.0)                                                PMT25240
825   FORMAT(5F10.0)                                                    PMT25250
830   FORMAT(8F9.0,2A4)                                                 PMT25260
C                                                                       PMT25270
C   OUTPUT FORMATS                                                      PMT25280
C                                                                       PMT25290
  900 FORMAT(1H1,37X,'POLLUTION EPISODIC MODEL (PEM-2)'///4X,'INPUT CONTPMT25300
     1ROL PARAMETERS:  ',20A4//)                                        PMT25310
  901 FORMAT(//4X,'INPUT CONTROL PARAMETERS:'//)                        PMT25320
  902 FORMAT(10X,'AVERAGING TIME OPTION: NTOPT=',I1//                   PMT25330
     1 18X,'A SCENARIO IS A SET OF METEOROLOGICAL DATA FOR ONE HOUR'//  PMT25340
     2 13X,'1  1 HOUR: CONCENTRATIONS ARE CALCULATED FOR EACH SCENARIO'/PMT25350
     3 13X,'2  24 HOURS: CONCENTRATIONS CALCULATED FOR 24 SCENARIOS ARE PMT25360
     4AVERAGED'/13X,'3  VARIABLE: CONCENTRATIONS CALCULATED FOR A GIVEN PMT25370
     5NUMBER (2 TO 23) OF SCENARIOS ARE AVERAGED'//)                    PMT25380
  904 FORMAT(10X,'WIND DIRECTION OPTION: NWDOPT=',I1//                  PMT25390
     113X,'0  DIRECTION IN DEGREES TO BE SPECIFIED FOR EACH SCENARIO'/  PMT25400
     213X,'1  SECTOR NUMBER TO BE SPECIFIED FOR EACH SCENARIO'/         PMT25410
     312X,'2-7 DIRECTION IN DEGREES TO BE SPECIFIED FOR THE FIRST OF FOUPMT25420
     4R SUB-SCENARIOS.'/17X,'FOR EACH SUCCEEDING SUB-SCENARIO, WIND DIREPMT25430
     5CTION IS AUTOMATICALLY INCREASED'/17X,'BY 90,45,30,15,10,OR 5 DEGRPMT25440
     6EES, DEPENDING ON THE OPTION NUMBER SELECTED.'//)                 PMT25450
  906 FORMAT(10X,'WIND SPEED OPTION: NWSOPT=',I1//                      PMT25460
     113X,'0  SPEED IN M/S TO BE SPECIFIED FOR EACH SCENARIO'/          PMT25470
     213X,'1  WIND SPEED CLASS NUMBER TO BE SPECIFIED FOR EACH SCENARIO'PMT25480
     3//)                                                               PMT25490
  907 FORMAT(10X,'WIND PROFILE EXPONENTS OPTION: NWPOPT=',I1//          PMT25500
     113X,'0  EXPONENTS AND ANEMOMETER HEIGHT ARE STANDARD DEFAULT VALUEPMT25510
     2S'/                                                               PMT25520
     313X,'1  EXPONENTS AND ANEMOMETER HEIGHT TO BE SPECIFIED BY THE USEPMT25530
     4R')                                                               PMT25540
  908 FORMAT(10X,'NUMBER OF SCENARIOS: NSCEN=',I2//)                    PMT25550
  910 FORMAT(//10X,'STACK-TIP DOWNWASH ALGORITHM OPTION: NSTDWN=',I1//  PMT25560
     1 13X,'0  ALGORITHM IS IN EFFECT'/                                 PMT25570
     2 13X,'1  ALGORITHM IS NOT USED'//)                                PMT25580
  911 FORMAT(10X,'NEW PLUME-RISE EQUATIONS OPTION: NPRISE=',I1//        PMT25590
     1 13X,'0  STANDARD PLUME-RISE EQS. ARE USED FOR ALL STABILITY CLASSPMT25600
     2ES'/                                                              PMT25610
     3 13X,'1  NEW EQS. ARE USED FOR PEAK BUOYANCY RISE FOR STABILITY CLPMT25620
     4ASSES A-D'//)                                                     PMT25630
  912 FORMAT(10X,'PLUME PENETRATION ABOVE MIXING HEIGHT OPTION: NINPEN='PMT25640
     1,I1//,                                                            PMT25650
     2 13X,'0  STANDARD TREATMENT OF PLUME PENETRATION ABOVE THE MIXING'PMT25660
     3,' HEIGHT'/,                                                      PMT25670
     4 13X,'1  NEW SCHEMES FOR PLUME PENETRATION OF ELEVATED STABLE LAYEPMT25680
     5R USED'/16X,' FOR STABILITY CLASSES A-D AND BUOYANCY-DOMINATED PLUPMT25690
     6ME'//)                                                            PMT25700
  914 FORMAT(10X,'AUTOMATIC RECEPTOR GRID OPTION IS IN EFFECT'//)       PMT25710
  916 FORMAT(10X,'RECEPTOR GRID:',                                      PMT25720
     16X,'COLUMNS: LX=',I3,4X,'ROWS: LY=',I3/                           PMT25730
     230X,'SPACING: GRID=',F7.3,' KM'/                                  PMT25740
     330X,'SOUTHWEST CORNER    XRSWC= ',F8.3,' KM W'/                   PMT25750
     450X,'YRSWC= ',F8.3,' KM S'//)                                     PMT25760
  920 FORMAT(10X,'POTENTIAL TEMPERATURE GRADIENT: DTDZ(1)= ',F7.3,      PMT25770
     1' DEG/M    STABILITY CLASS E'/                                    PMT25780
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   242X,'DTDZ(2)= ',F7.3,' DEG/M    STABILITY CLASS F'//)                PMT25790
921 FORMAT(1H+,85X,7A4)                                                   PMT25800
922 FORMAT(10X,'NUMBER OF POLLUTANTS: NPOL=',I1/                          PMT25810
   1 51X,'POLLUTANT-1: ',3A4)                                             PMT25820
923 FORMAT(1H+,85X,'POLLUTANT-2: ',3A4)                                   PMT25830
924 FORMAT(/10X,'AREA SOURCE SCALING FACTOR:',17X,'ASCALE=',F9.3)         PMT25840
925 FORMAT(10X,'CALIBRATION COEFFICIENTS:',                               PMT25850
   1 16X,'A=',F10.3,'  B=',F10.3)                                         PMT25860
926 FORMAT(1H+,85X,'A=',F10.3,'  B=',F10.3)                               PMT25870
927 FORMAT(10X,'CALIBRATION IDENTIFICATION:',14X,7A4,6X,7A4)              PMT25880
928 FORMAT(10X,'DEPOSITION VELOCITY (CM/S):',20X,'VD1=',F8.3)             PMT25890
929 FORMAT(10X,'SETTLING VELOCITY (CM/S):',23X,'W1=',F8.3)                PMT25900
930 FORMAT(//10X,'CHEMICAL TRANSFORMATION OPTION: ICT=',I1/)              PMT25910
931 FORMAT(1H+,91X,'VD2=',F8.3)                                           PMT25920
932 FORMAT(13X,'NPOL=1'/                                                  PMT25930
   215X,'ICT=0  CHEMICAL TRANSFORMATION LOSS OF POLLUTANT IS IGNORED'/PMT25940
   315X,'ICT=1  FIRST-ORDER CHEMICAL TRANSFORMATION LOSS OF POLLUTANT PMT25950
   4IS CONSIDERED'//)                                                     PMT25960
933 FORMAT(1H+,92X,'W2=',F8.3)                                            PMT25970
934 FORMAT(13X,'NPOL=2'/                                                  PMT25980
   215X,'ICT=0  CHEMICAL TRANSFORMATION LOSS OF POLLUTANTS IS IGNORED'PMT25990
   3/15X,'ICT=1  FIRST-ORDER CHEMICAL TRANSFORMATION OF POLLUTANT-1 TOPMT26000
   4 POLLUTANT-2 IS CONSIDERED'//)                                        PMT26010
935 FORMAT(1H+,88X,'ASCALE=',F9.3)                                        PMT26020
936 FORMAT(10X,'CHEMICAL TRANSFORMATION OR DECAY RATE: XKT=',F7.3,        PMT26030
   1' PERCENT/HR'/)                                                       PMT26040
938 FORMAT(10X,'RATIO OF MOLECULAR WEIGHTS OF POLLUTANT-2 (PRODUCT) TOPMT26050
   1 POLLUTANT-1 (REACTANT): GAMMA=',F6.3/)                               PMT26060
940 FORMAT(10X,'OUTPUT OPTIONS SELECTED:'//)                              PMT26070
942 FORMAT(13X,'NLIST=',I1,3X,'LISTS OF CONCENTRATION AND SURFACE DEPOPMT26080
   1SITION FLUX AT EACH RECEPTOR IN THE GRID,'/24X,'ONE COLUMN PER PAGPMT26090
   2E')                                                                   PMT26100
944 FORMAT(13X,'NARRAY=',I1,2X,'MAPS OF CONCENTRATION AND SURFACE DEPOPMT26110
   1SITION FLUX AT EACH RECEPTOR IN THE GRID,')                           PMT26120
946 FORMAT(24X,'CALIBRATED AND UNCALIBRATED')                             PMT26130
948 FORMAT(24X,'UNCALIBRATED ONLY')                                       PMT26140
950 FORMAT(24X,'CALIBRATED ONLY')                                         PMT26150
952 FORMAT(13X,'NTAPE=',I1,3X,'TAPE CONTAINING COORDINATES, CONCENTRATPMT26160
   1ION, AND SURFACE DEPOSITION FLUX'/24X,'AT EACH RECEPTOR IN THE GRIPMT26170
   2D'/13X,'INTER=',I2,2X,'INTERVAL OF RECEPTORS WHICH WILL BE WRITTENPMT26180
   3 ON TAPE')                                                            PMT26190
954 FORMAT(13X,'NCSOPT=',I1,2X,'LIST OF POINT SOURCE CULPABILITY FOR CPMT26200
   1ONCENTRATION AND SURFACE DEPOSITION FLUX'/24X,'AT EACH RECEPTOR INPMT26210
   2 THE GRID'//)                                                         PMT26220
956 FORMAT(13X,'NPRINT=',I1,2X,'LIST OF POINT SOURCE PARAMETERS AND EFPMT26230
   1FECTIVE STACK HEIGHTS'/24X,'PRINTED AT BEGINNING OF EACH SCENARIO'PMT26240
   2//)                                                                   PMT26250
958 FORMAT(13X,'NMAX=',I1,4X,'LIST OF RECEPTORS WITH HIGHEST CONCENTRAPMT26260
   1TION AND SURFACE DEPOSITION FLUX'/24X,'FOR EACH SCENARIO - PRINTEDPMT26270
   2 AT END OF RUN')                                                      PMT26280
959 FORMAT(/16X,'USER SPECIFIED WIND PROFILE EXPONENT VALUES:'/20X,      PMT26290
   16(F4.2,3X)/20X,'ANEMOMETER HEIGHT = ',F4.1,1X,'METERS',               PMT26300
   23X,'HMIN =',1X,F4.1,' ,HMAX = ',F4.0,' ,UMIN = ',F3.1)                PMT26301
960 FORMAT(1H1,37X,'POLLUTION EPISODIC MODEL (PEM-2)'///4X,'INPUT SCENPMT26310
   1ARIO PARAMETERS:  ',20A4//26X,'WIND DIRECTIONS',27X,'WIND SPEED CLPMT26320
   2ASSES',12X,'STABILITY CLASSES'/)                                      PMT26330
962 FORMAT(10X,'SECTOR    DIRECTION',6X,'SECTOR    DIRECTION',9X,        PMT26340
   1'CLASS   SPEED    CLASS',15X,'CLASS'/                                 PMT26350
   210X,'NUMBER',8X,'(DEG)',6X,'NUMBER',8X,'(DEG)',9X,'INDEX   (M/S)      PMT26360
   3 INTERVAL(KT)',9X,'INDEX   CLASS'//13X,'1    N',7X,'0.0',9X,'9       PMT26370
   4S',5X,'180.0'/13X,'2    NNE    22.5',8X,'10    SSW   202.5',11X,     PMT26380
   5'1',6X,'1.50',7X,'0-3',16X,'1',7X,'A'/13X,'3    NE',5X,'45.0',8X,    PMT26390
   6'11    SW    225.0',11X,'2',6X,'2.46',7X,'4-6',16X,'2',7X,'B')        PMT26400
963 FORMAT(13X,'4    ENE    67.5',8X,'12    WSW   247.5',11X,'3',6X,     PMT26410
   1'4.47',7X,'7-10',15X,'3',7X,'C'/13X,'5    E',6X,'90.0',8X,'13    WPMT26420
   2',5X,'270.0',11X,'4',6X,'6.93',6X,'11-16',15X,'4',7X,'D'/            PMT26430
   313X,'6    ESE   112.5',8X,'14    WNW   292.5',11X,'5',6X,'9.61',      PMT26440
   46X,'17-21',15X,'5',7X,'E'/13X,'7    SE    135.0',8X,'15    ',        PMT26450
   5 'NW    315.0',11X,'6',5X,'12.52    OVER 21',15X,'6',7X,'F'/          PMT26460
   613X,'8    SSE   157.5',8X,'16    NNW   337.5'///)                     PMT26470
964 FORMAT(5X,'SCENARIO',3X,'STABILITY',3X,'WIND SPEED',5X,'WIND',8X,     PMT26480
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     1'WIND',6X,'WIND',8X,'AMBIENT',4X,'TEMP GRADIENT ABOVE',8X,        PMT26490
     2'MIXING'/6X,'NUMBER',6X,'CLASS',7X,'CLASS',8X,'SPEED',6X,         PMT26500
     3'SECTOR',3X,'DIRECTION',3X,'TEMPERATURE',5X,'MIXING HEIGHT',      PMT26510
     411X,'HEIGHT'/43X,'(M/S)',17X,'(DEG)',7X,'(DEG C)',10X,            PMT26520
     5'(DEG/M)',15X,'(M)'/)                                             PMT26530
  966 FORMAT(8X,I2,10X,A2)                                              PMT26540
  970 FORMAT(1H+,31X,I1)                                                PMT26550
  972 FORMAT(1H+,42X,F6.3)                                              PMT26560
  973 FORMAT(1H+,63X,F6.2)                                              PMT26570
  974 FORMAT(1H+,55X,I2)                                                PMT26580
  978 FORMAT(1H+,76X,F7.2,11X,F6.3,11X,F7.1)                            PMT26590
  979 FORMAT(1H+,76X,F7.2,28X,F7.1)                                     PMT26600
  980 FORMAT(1H1,37X,'POLLUTION EPISODIC MODEL (PEM-2)'///4X,'INPUT POINPMT26610
     1T SOURCE PARAMETERS:  ',20A4///                                   PMT26620
     26X,'POINT SOURCE',10X,'COORDINATES',9X,'EMISSION RATE',           PMT26630
     36X,'EMISSION RATE',5X,'HEIGHT',4X,'DIAMETER',4X,'EXIT VEL',5X,    PMT26640
     4'EXIT TEMP'/5X,'NUMBER',3X,'LABEL',7X,'X(KM)',5X,'Y(KM)',6X,      PMT26650
     5'POLLUTANT-1 (G/S)',2X,'POLLUTANT-2 (G/S)',3X,'(M)',8X,'(M)',8X,  PMT26660
     6'(M/S)',8X,'(DEG C)'/)                                            PMT26670
  984 FORMAT(6X,I3,3X,2A4,3X,F8.2,2X,F8.2,10X,F9.3,10X,F9.3,6X,F6.2,5X, PMT26680
     1F6.3,6X,F7.3,6X,F8.3)                                             PMT26690
  986 FORMAT(1H0,5X,'SUMS OF THE POINT SOURCE EMISSION RATES',6X,F9.3,  PMT26700
     1' G/S',6X,F9.3,' G/S')                                            PMT26710
  990 FORMAT(1H1,37X,'POLLUTION EPISODIC MODEL (PEM-2)'///4X,'INPUT AREAPMT26720
     1 SOURCE PARAMETERS:  ',20A4///                                    PMT26730
     270X,'POLLUTANT-1',17X,'POLLUTANT-2'/5X,'AREA SOURCE',8X,          PMT26740
     3'COORDINATES',9X,'LENGTH OF SIDE',11X,'EMISSION RATE',15X,        PMT26750
     4'EMISSION RATE'/                                                  PMT26760
     57X,'NUMBER',9X,'X(KM)',5X,'Y(KM)',13X,'(M)',12X,'INPUT (G/S)',    PMT26770
     64X,'SCALED',7X,'INPUT (G/S)',4X,'SCALED'/)                        PMT26780
  992 FORMAT(9X,I2,8X,F8.2,2X,F8.2,10X,F8.2,9X,F9.3,4X,F9.3,6X,         PMT26790
     1 F9.3,4X,F9.3)                                                    PMT26800
  994 FORMAT(1H0,18X,'SUMS OF THE AREA SOURCE EMISSION RATES',          PMT26810
     1 7X,F9.3,4X,F9.3,6X,F9.3,4X,F9.3)                                 PMT26820
  996 FORMAT(/17X,'EFFECTIVE HEIGHT OF THE AREA SOURCE EMISSIONS',      PMT26830
     1 ' = ',F6.2,' M')                                                 PMT26840
      END                                                               PMT26850
C
C                                                                       PMT26860
C                                                                       PMT26870
      SUBROUTINE OUTMOD                                                 PMT26880
C                    SUBROUTINE OUTMOD , PART OF PEM-2 (VERSION 84130)..PMT26890
C                                                                       PMT26900
C                                                                       PMT26910
C     SUBROUTINE OUTMOD COORDINATES OUTPUT OF THE CONCENTRATION(S)      PMT26920
C     AND SURFACE DEPOSITION FLUX(ES) CALCULATED FOR EACH RECEPTOR      PMT26930
C     IN THE GRID FOR EACH SCENARIO OR AVERAGING-PERIOD.                PMT26940
C     ON OPTION, THE OUTPUT MAY BE IN THE FORM OF LISTS, ARRAY          PMT26950
C     MAPS, OR TAPE.                                                    PMT26960
C     ON OPTION, OUTMOD CALLS SUBROUTINE WOROUT TO PRINT A CULPABILITY  PMT26970
C     LIST OF POINT SOURCES.                                            PMT26980
C     OUTMOD ALSO CALLS SUBROUTINE SCENMX TO DETERMINE AND STORE THE    PMT26990
C     RECEPTORS WITH MAXIMUM CONCENTRATION(S) AND SURFACE DEPOSITION    PMT27000
C     FLUX(ES) FOR THE AVERAGING-PERIOD.                                PMT27010
C                                                                       PMT27020
C                                                                       PMT27030
C *** PEM MODIFICATIONS AND FORMATS BY MARTHA M. STEVENS,               PMT27040
C     NOAA-ATDL, P.O. BOX-E, OAK RIDGE, TENN 37831                      PMT27050
C     DECEMBER 1982                                                     PMT27060
C *** PEM-2 MODIFICATIONS BY K. SHANKAR RAO                             PMT27070
C     DECEMBER 1984                                                     PMT27080
C                                                                       PMT27090
C                                                                       PMT27100
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                  PMT27110
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),       PMT27120
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                 PMT27130
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                         PMT27140
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),              PMT27150
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),          PMT27160
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,                PMT27170
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     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                   PMT27180
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,                PMT27190
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,      PMT27200
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT27210
C                                                                       PMT27220
      COMMON/PARM1/NPOL,VD1,W1,VD2,W2                                   PMT27230
      DIMENSION CON(2),CALCON(2),SD(2),CALSD(2),AVD(2)                  PMT27240
C                                                                       PMT27250
C                                                                       PMT27260
C     CONTROL STRATEGY RESULTS OUTPUT BY SUBROUTINE WOROUT              PMT27270
      IF(NCSOPT.GT.0) CALL WOROUT                                       PMT27280
C                                                                       PMT27290
C     PRINT AND/OR WRITE-ON-TAPE LISTS OF CONCENTRATION(S) AND          PMT27300
C     SURFACE DEPOSITION FLUX(ES)                                       PMT27310
      IF(NLIST.EQ.0 .AND. NTAPE.EQ.0) GO TO 350                         PMT27320
      IF(NTAPE.GT.0) WRITE(ITA,900)TT                                   PMT27330
C                                                                       PMT27340
      NDEP=0                                                            PMT27350
      IF(VD1.GE.0.01.OR.VD2.GE.0.01) GO TO 100                          PMT27360
      GO TO 150                                                         PMT27370
  100 NDEP=1                                                            PMT27380
C     DEFINE CALIBRATION COEFFICIENTS FOR DEPOSITION FLUX               PMT27390
      AVD(1)=A(1)*VD1*36.                                               PMT27400
      AVD(2)=A(2)*VD2*36.                                               PMT27410
C                                                                       PMT27420
  150 IF(NLIST.EQ.0) GO TO 200                                          PMT27430
      WOUT=WD(ISCEN)*180./3.1415927                                     PMT27440
C     PRINT TITLE, SCENARIO, AND AVERAGING-PERIOD INFORMATION           PMT27450
      IF(NTOPT.EQ.1) WRITE(IWR,905)TT,ISCEN,SCLAB(ISC),WS(ISCEN),WOUT,  PMT27460
     1 HMIX(ISCEN),IAV                                                  PMT27470
      IF(NTOPT.GT.1) WRITE(IWR,906) TT,ISCEN,IAV                        PMT27480
C     PRINT TITLES FOR UNCALIBRATED CONCENTRATION AND DEPOSITION FLUX,  PMT27490
C     AND CALIBRATED CONCENTRATION                                      PMT27500
      WRITE(IWR,910)(CALNAM(L,1),L=1,7),(CALNAM(L,2),L=1,7)             PMT27510
C                                                                       PMT27520
C     BEGIN DO-LOOP ON RECEPTOR GRID COLUMNS                            PMT27530
  200 DO 325 I=1,LX                                                     PMT27540
      XI=I                                                              PMT27550
      X=XSWC+(XI-0.5)*GRID                                              PMT27560
C                                                                       PMT27570
C     BEGIN DO-LOOP ON RECPTOR GRID ROWS                                PMT27580
      DO 300 J=1,LY                                                     PMT27590
      YJ=J                                                              PMT27600
      Y=YSWC+(YJ-0.5)*GRID                                              PMT27610
C                                                                       PMT27620
C     INITIALIZE CONCENTRATION AND SDF VARIABLES                        PMT27630
      DO 260 K=1,2                                                      PMT27640
      CON(K)=0.                                                         PMT27650
      CALCON(K)=0.                                                      PMT27660
      SD(K)=0.                                                          PMT27670
      CALSD(K)=0.                                                       PMT27680
  260 CONTINUE                                                          PMT27690
C                                                                       PMT27700
C     DEFINE AND PRINT UNCALIBRATED CONCENTRATIONS AND DEPOSITION FLUXESPMT27710
C     AND CALIBRATED CONCENTRATIONS                                     PMT27720
      DO 280 K=1,NPOL                                                   PMT27730
      CON(K)=CONC(I,J,K)                                                PMT27740
      CALCON(K)= A(K) + B(K) * CON(K)                                   PMT27750
      IF(NDEP.EQ.0) GO TO 280                                           PMT27760
      SD(K)=SDF(I,J,K)                                                  PMT27770
      IF(NTAPE.GT.0) CALSD(K)= AVD(K) + B(K) * SD(K)                    PMT27780
  280 CONTINUE                                                          PMT27790
C                                                                       PMT27800
      IF(NLIST.EQ.0) GO TO 290                                          PMT27810
      IF(CON(1).LT.1.0.AND.CON(2).LT.1.0) GO TO 290                     PMT27820
      WRITE(IWR,970) I,J,X,Y,CON(1),CON(2),SD(1),SD(2),                 PMT27830
     1 CALCON(1),CALCON(2)                                              PMT27840
C                                                                       PMT27850
C     WRITE ON TAPE ALL CALIBRATED AND UNCALIBRATED OUTPUT DATA         PMT27860
  290 IF(NTAPE.EQ.0) GO TO 300                                          PMT27870
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      IF(((I-1)/INTER)*INTER.NE.(I-1).OR.((J-1)/INTER)*INTER.NE.
     1 (J-1)) GO TO 300
      WRITE(ITA,975)X,Y,(CON(K),SD(K),CALCON(K),CALSD(K),K=1,2)
  300 CONTINUE
C
C     END LOOP ON GRID ROWS
  325 CONTINUE
C     END LOOP ON GRID COLUMNS
C
C
C     PRINT ARRAY MAPS OF CONCENTRATIONS
  350 IF(NARRAY.GT.0) CALL ARRAY
C
C  DETERMINE MAXIMUM PREDICTED CONCENTRATION(S) FOR SCENARIO VIA SCENMX
      IF(NMAX.GT.0.AND.(NTOPT.EQ.1.OR.ISCEN.EQ.NSCEN)) CALL SCENMX
C
      RETURN
C
  900 FORMAT(20A4)
  905 FORMAT(1H1,'PEM-2 OUTPUT:  PREDICTED CONCENTRATIONS:  ',
     120A4/' SCENARIO ',I2,', STABILITY=',A2,', WIND SPEED=',F5.2,' M/S,
     2 WIND DIRECTION=',F6.2,' DEG, MIXING HEIGHT=',F7.1,' M, AVERAGING
     3TIME=',I2,' HR.'//)
  906 FORMAT(1H1,'PEM-2 OUTPUT:  PREDICTED CONCENTRATIONS:  ',
     120A4/1X,I2,' SCENARIOS,',2X,'AVERAGING TIME=',I3,' HRS.'//)
  910 FORMAT(15X,'RECEPTOR',4X,'UNCALIBRATED CONCENTRATION',2X,'UNCALIB.
     1DEPOSITION FLUX',2X,'CALIBRATED CONCEN.POL-1:',7A4/14X,'COORDINATE
     2S',3X,'(MICROGRAMS/CUBIC METER)',3X,'(MICROGRAMS/SQ.M/HOUR)',3X,
     3'CALIBRATED CONCEN.POL-2:',7A4/1X,'COL ROW',5X,'X(KM)',3X,'Y(KM)',
     44X,'POL-1',11X,'POL-2',9X,'POL-1',8X,'POL-2',4X,'POL-1',8X,'POL-2'
     5/)
  970 FORMAT(2(2X,I2),2X,2(2X,F6.2),2X,F8.2,8X,F8.2,2(3X,F10.1),
     1 2(2X,E11.4))
  975 FORMAT(10F8.2)
      END
C
C
C
      SUBROUTINE ARRAY
C                     SUBROUTINE ARRAY  , PART OF PEM-2 (VERSION 84130).
C
C
C  SUBROUTINE ARRAY CREATES ARRAY MAPS OF THE CONCENTRATIONS AND
C    SURFACE DEPOSITION FLUXES IN THE RECEPTOR GRID AND
C    PRINTS THEM AT THE END OF EACH SCENARIO OR AVERAGING PERIOD.
C    UNCALIBRATED AND CALIBRATED CONCENTRATIONS OF EACH POLLUTANT
C    APPEAR ON SEPARATE MAPS OF UP TO FOUR SECTIONS (PAGES) EACH.
C    EACH SECTION (PAGE) ACCOMODATES VALUES AT 25X25 RECEPTORS.
C
C
C *** PEM MODIFICATIONS AND FORMATS BY M.M. STEVENS,
C     NOAA-ATDL, P.O. BOX E, OAK RIDGE, TN 37831
C     DECEMBER 1982
C *** PEM-2 MODIFICATIONS AND FORMATS BY K. SHANKAR RAO
C     JULY 1984
C
C
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),
     2 XA(50),YA(50),EA(50,2),SIZE(50),
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID
C
      COMMON/PARM1/NPOL,VD1,W1,VD2,W2
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      DIMENSION X(50),CC(50),SSDF(50),DV(2),AVD(2)                      PMT28570
      INTEGER CC,SSDF                                                   PMT28580
C                                                                       PMT28590
      DV(1)=VD1                                                         PMT28600
      DV(2)=VD2                                                         PMT28610
      WOUT= WD(ISCEN)*180./3.1415927                                    PMT28620
      NLX=1                                                             PMT28630
      NLY=1                                                             PMT28640
      IF(LX.GT.25) NLX=2                                                PMT28650
      IF(LY.GT.25) NLY=2                                                PMT28660
      NSECT=NLX*NLY                                                     PMT28670
C                                                                       PMT28680
  100 ISECT=0                                                           PMT28690
      DO 700 JLX=1,NLX                                                  PMT28700
      MX2= JLX*25                                                       PMT28710
      IF(MX2.GT.LX) MX2=LX                                              PMT28720
      MX1=1                                                             PMT28730
      IF(JLX.EQ.2) MX1=26                                               PMT28740
      DO 125 I=MX1,MX2                                                  PMT28750
      XI=I                                                              PMT28760
125   X(I)= XSWC + (XI-0.5)*GRID                                        PMT28770
      DO 600 JLY=1,NLY                                                  PMT28780
      ISECT=ISECT+1                                                     PMT28790
      IF(JLY.EQ.1) GO TO 150                                            PMT28800
      MY1=26                                                            PMT28810
      MY2=LY                                                            PMT28820
      GO TO 175                                                         PMT28830
150   MY1=1                                                             PMT28840
      MY2=25                                                            PMT28850
      IF(LY.LT.25) MY2=LY                                               PMT28860
C                                                                       PMT28870
C                                                                       PMT28880
175   DO 500 N=1,NPOL                                                   PMT28890
      NREP=0                                                            PMT28900
  180 IF(NARRAY.EQ.3) GO TO 181                                         PMT28910
C     PRINT UNCALIBRATED ARRAYS OF CONCENTRATION AND DEPOSITION FLUX    PMT28920
C     (FOR NARRAY = 1 OR 2)                                             PMT28930
      IF(NTOPT.EQ.1) WRITE(IWR,900)ISECT,NSECT,ISCEN,TT                 PMT28940
      IF(NTOPT.GT.1) WRITE(IWR,901)ISECT,NSECT,TT                       PMT28950
      IF(NTOPT.EQ.1)WRITE(IWR,902)SCLAB(ISC),WS(ISCEN),WOUT,HMIX(ISCEN),PMT28960
     1              IAV,N,(POLNAM(L,N),L=1,3)                           PMT28970
      IF(NTOPT.GT.1) WRITE(IWR,903)ISCEN,IAV,N,(POLNAM(L,N),L=1,3)      PMT28980
C                                                                       PMT28990
      IF(NREP.EQ.0) GO TO 185                                           PMT29000
C    LOOP THROUGH SDF ARRAY TO FIND ANY VALUE GE 1000. IN THAT CASE,    PMT29010
C     SET FLAG TO SCALE SDF VALUES AS THEY ARE SET IN SSDF ARRAY        PMT29020
  181 IFLAG=0                                                           PMT29030
      DO 183 NX=1,LX                                                    PMT29040
      DO 183 NY=1,LY                                                    PMT29050
      IF(NARRAY.EQ.3) GO TO 182                                         PMT29060
      IF(SDF(NX,NY,N).GT.999.49) GO TO 184                              PMT29070
      GO TO 183                                                         PMT29080
  182 DUMMY=AVD(N)+B(N)*SDF(NX,NY,N)                                    PMT29090
      IF(DUMMY.GT.999.49) GO TO 184                                     PMT29100
  183 CONTINUE                                                          PMT29110
      IF(NARRAY.EQ.3) GO TO 320                                         PMT29120
      WRITE(IWR,905)                                                    PMT29130
      GO TO 190                                                         PMT29140
  184 IFLAG=1                                                           PMT29150
      IF(NARRAY.EQ.3) GO TO 320                                         PMT29160
      WRITE(IWR,910)                                                    PMT29170
      GO TO 190                                                         PMT29180
  185 WRITE(IWR,904)                                                    PMT29190
  190 WRITE(IWR,915) (X(I),I=MX1,MX2,2)                                 PMT29200
      DO 300 J=MY1,MY2                                                  PMT29210
      IY= MY2 + MY1 - J                                                 PMT29220
      Y=IY                                                              PMT29230
      Y= YSWC + (Y-0.5)*GRID                                            PMT29240
C                                                                       PMT29250
      IF(NREP.EQ.1) GO TO 240                                           PMT29260
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      DO 230 I=MX1,MX2                                                  PMT29270
230   CC(I)= CONC(I,IY,N) + 0.5                                         PMT29280
      WRITE(IWR,920)Y,(CC(I),I=MX1,MX2)                                 PMT29290
      GO TO 300                                                         PMT29300
  240 DO 250 I=MX1,MX2                                                  PMT29310
      IF(IFLAG.EQ.0) GO TO 245                                          PMT29320
      SSDF(I)=SDF(I,IY,N)*1.0E-03 + 0.5                                 PMT29330
      GO TO 250                                                         PMT29340
  245 SSDF(I)= SDF(I,IY,N) + 0.5                                        PMT29350
  250 CONTINUE                                                          PMT29360
      WRITE(IWR,920) Y,(SSDF(I),I=MX1,MX2)                              PMT29370
300   WRITE(IWR,925)Y                                                   PMT29380
      WRITE(IWR,915)(X(I),I=MX1,MX2,2)                                  PMT29390
      IF(NARRAY.EQ.2) GO TO 450                                         PMT29400
C                                                                       PMT29410
C                                                                       PMT29420
C     PRINT CALIBRATED ARRAYS OF CONCENTRATION (FOR NARRAY = 1 OR 3)    PMT29430
C     AND DEPOSITION FLUX (FOR NARRAY = 3 ONLY)                         PMT29440
  320 IF(NTOPT.EQ.1) WRITE(IWR,900)ISECT,NSECT,ISCEN,TT                 PMT29450
      IF(NTOPT.GT.1) WRITE(IWR,901)ISECT,NSECT,TT                       PMT29460
      IF(NTOPT.EQ.1)WRITE(IWR,902)SCLAB(ISC),WS(ISCEN),WOUT,HMIX(ISCEN),PMT29470
     1              IAV,N,(POLNAM(L,N),L=1,3)                           PMT29480
      IF(NTOPT.GT.1) WRITE(IWR,903)ISCEN,IAV,N,(POLNAM(L,N),L=1,3)      PMT29490
      IF(NREP.EQ.0) WRITE(IWR,906)(CALNAM(L,N),L=1,7),A(N),B(N)         PMT29500
      IF(NARRAY.EQ.1) GO TO 322                                         PMT29510
      IF(NREP.EQ.0) GO TO 322                                           PMT29520
      IF(IFLAG.EQ.0) WRITE(IWR,907)                                     PMT29530
      IF(IFLAG.EQ.1) WRITE(IWR,909)                                     PMT29540
C                                                                       PMT29550
  322 WRITE(IWR,915)(X(I),I=MX1,MX2,2)                                  PMT29560
      DO 400 J=MY1,MY2                                                  PMT29570
      IY= MY2 + MY1 - J                                                 PMT29580
      Y=IY                                                              PMT29590
      Y= YSWC + (Y-0.5)*GRID                                            PMT29600
C                                                                       PMT29610
      IF(NREP.EQ.1) GO TO 340                                           PMT29620
      DO 330 I=MX1,MX2                                                  PMT29630
330   CC(I)= A(N) + B(N)*CONC(I,IY,N) + 0.5                             PMT29640
      WRITE(IWR,920)Y,(CC(I),I=MX1,MX2)                                 PMT29650
      GO TO 400                                                         PMT29660
  340 IF(NARRAY.EQ.1) GO TO 500                                         PMT29670
      DO 350 I=MX1,MX2                                                  PMT29680
      SSDF(I)= AVD(N) + B(N) * SDF(I,IY,N)                              PMT29690
      IF(IFLAG.EQ.1) SSDF(I)=SSDF(I)*1.0E-03                            PMT29700
      SSDF(I)=SSDF(I)+0.5                                               PMT29710
  350 CONTINUE                                                          PMT29720
      WRITE(IWR,920) Y,(SSDF(I),I=MX1,MX2)                              PMT29730
400   WRITE(IWR,925)Y                                                   PMT29740
      WRITE(IWR,915)(X(I),I=MX1,MX2,2)                                  PMT29750
C                                                                       PMT29760
  450 IF(NREP.EQ.1) GO TO 500                                           PMT29770
C   IF NO SURF DEP FLUX WAS CALCULATED, SKIP PRINT                      PMT29780
      IF(DV(N).LE.0.01) GO TO 500                                       PMT29790
      NREP=1                                                            PMT29800
      AVD(N)=A(N)*DV(N)*36.                                             PMT29810
      GO TO 180                                                         PMT29820
500   CONTINUE                                                          PMT29830
600   CONTINUE                                                          PMT29840
700   CONTINUE                                                          PMT29850
C                                                                       PMT29860
      RETURN                                                            PMT29870
C                                                                       PMT29880
900   FORMAT(1H1,'PEM-2 OUTPUT:  ','SECTION ',I1,' OF ',I1,', SCENARIO 'PMT29890
     1,I2,2X,20A4)                                                      PMT29900
  901 FORMAT(1H1,'PEM-2 OUTPUT:  ','SECTION ',I1,' OF ',I1,3X,          PMT29910
     1 20A4)                                                            PMT29920
902   FORMAT(' STABILITY=',A2,' WIND SPD=',F5.2,' M/S, WIND DIR=',F6.2,PMT29930
     1 ' DEG, MIXING HT=',F7.1,' M, AVERAGING TIME=',I2,' HR.',6X,      PMT29940
     2 'POLLUTANT-',I1,': ',3A4)                                        PMT29950
  903 FORMAT(1X,I2,' SCENARIOS,',2X,'AVERAGING TIME=',I3,' HRS.',64X,   PMT29960
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     1 'POLLUTANT-',I1,': ',3A4)                                        PMT29970
904   FORMAT(' UNCALIBRATED CONCENTRATION - MICROGRAMS PER CUBIC METER')PMT29980
  905 FORMAT(' UNCALIBRATED SURFACE DEPOSITION FLUX - MICROGRAMS PER SQUPMT29990
     1ARE METER PER HOUR')                                              PMT30000
906   FORMAT(' CALIBRATED CONCENTRATION - ',7A4,18X,'CALIBRATION COEFFICPMT30010
     1IENTS:  A =',F11.4,',   B =',F11.4)                              PMT30020
  907 FORMAT(' CALIBRATED SURFACE DEPOSITION FLUX - MICROGRAMS PER SQUARPMT30030
     1E METER PER HOUR')                                                PMT30040
  909 FORMAT(' CALIBRATED SURFACE DEPOSITION FLUX - KILOGRAMS PER SQUAREPMT30050
     1 KILOMETER PER HOUR')                                             PMT30060
  910 FORMAT(' UNCALIBRATED SURFACE DEPOSITION FLUX - KILOGRAMS PER SQUAPMT30070
     1RE KILOMETER PER HOUR')                                           PMT30080
915   FORMAT(1H0,14X,13F8.2)                                           PMT30090
920   FORMAT(1H0,4X,F8.2,4X,25I4)                                      PMT30100
925   FORMAT(1H+,122X,F8.2)                                            PMT30110
      END                                                              PMT30120
C
C                                                                      PMT30130
C                                                                      PMT30140
      SUBROUTINE WORST(I,J,CHI,N)                                      PMT30150
C                    SUBROUTINE WORST  , PART OF PEM-2 (VERSION 84130). PMT30160
C                                                                      PMT30170
C                                                                      PMT30180
C  SUBROUTINE WORST DETERMINES THE FIVE POINT SOURCES CONTRIBUTING THE PMT30190
C    MOST TO THE TOTAL CONCENTRATION AT EACH RECEPTOR. SOURCE          PMT30200
C    IDENTIFICATIONS AND CONTRIBUTIONS ARE STORED IN NWORST AND CWORST PMT30210
C    RESPECTIVELY, FOR OUTPUT BY SUBROUTINE WOROUT.                    PMT30220
C                                                                      PMT30230
C                                                                      PMT30240
C *** PEM MODIFICATIONS BY M.M. STEVENS,                               PMT30250
C     NOAA-ATDL, P.O. BOX-E, OAK RIDGE, TENN 37831                     PMT30260
C     DECEMBER 1982                                                    PMT30270
C                                                                      PMT30280
C *** PEM-2 MODIFICATIONS BY K. S. RAO                                 PMT30290
C     DECEMBER 1984                                                    PMT30300
C                                                                      PMT30310
C                                                                      PMT30320
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                 PMT30330
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),      PMT30340
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                PMT30350
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                        PMT30360
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),             PMT30370
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),         PMT30380
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,               PMT30390
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                  PMT30400
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,               PMT30410
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,     PMT30420
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT30430
C                                                                      PMT30440
      COMMON/CSWOR/NWORST(25,25,5,2),CWORST(25,25,5,2)                 PMT30450
C                                                                      PMT30460
C                                                                      PMT30470
      IF(CHI.LE.CWORST(I,J,5,N)) RETURN                                PMT30480
      IF(CHI.GT.CWORST(I,J,4,N)) GO TO 205                             PMT30490
      CWORST(I,J,5,N)= CHI                                             PMT30500
      NWORST(I,J,5,N)= IPS                                             PMT30510
      RETURN                                                           PMT30520
205   IF(CHI.GT.CWORST(I,J,3,N)) GO TO 210                             PMT30530
      NW=1                                                             PMT30540
      GO TO 225                                                        PMT30550
210   IF(CHI.GT.CWORST(I,J,2,N)) GO TO 215                             PMT30560
      NW=2                                                             PMT30570
      GO TO 225                                                        PMT30580
215   IF(CHI.GT.CWORST(I,J,1,N)) GO TO 220                             PMT30590
      NW=3                                                             PMT30600
      GO TO 225                                                        PMT30610
220   NW=4                                                             PMT30620
225   DO 250 IW=1,NW                                                   PMT30630
      CWORST(I,J,6-IW,N)= CWORST(I,J,5-IW,N)                           PMT30640
250   NWORST(I,J,6-IW,N)= NWORST(I,J,5-IW,N)                           PMT30650
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      CWORST(I,J,5-NW,N)= CHI                                           PMT30660
      NWORST(I,J,5-NW,N)= IPS                                           PMT30670
      RETURN                                                            PMT30680
      END                                                               PMT30690
C
C                                                                       PMT30700
C                                                                       PMT30710
      SUBROUTINE WOROUT                                                 PMT30720
C                    SUBROUTINE WOROUT , PART OF PEM-2 (VERSION 84130). PMT30730
C                                                                       PMT30740
C                                                                       PMT30750
C  SUBROUTINE WOROUT PRINTS A CULPABILITY LIST OF THE FIVE POINT SOURCESPMT30760
C    WHICH CONTRIBUTE MOST TO THE TOTAL CONCENTRATION OF EACH POLLUTANT.PMT30770
C    THIS ROUTINE LISTS THE FIVE POINT SOURCES AND THEIR PERCENTAGE     PMT30780
C    CONTRIBUTIONS TO THE TOTAL CONCENTRATION AND SURFACE DEPOSITION    PMT30790
C    FLUX AT EACH RECEPTOR.                                             PMT30800
C    TO REDUCE OUTPUT, ONLY RECEPTORS WITH THE HIGHEST CONTRIBUTIONS    PMT30810
C    EXCEEDING 1 MICROGRAM PER CUBIC METER ARE PRINTED.                 PMT30820
C    USING DATA COMPILED BY SUBROUTINE WORST, THIS INFORMATION IS       PMT30830
C    PRINTED AT THE END OF EACH SCENARIO OR SUB-SCENARIO FOR NTOPT=1.   PMT30840
C                                                                       PMT30850
C                                                                       PMT30860
C *** PEM MODIFICATIONS AND FORMATS BY M.M. STEVENS,                    PMT30870
C     NOAA-ATDL, P.O. BOX E, OAK RIDGE, TN 37831                        PMT30880
C     DECEMBER 1982                                                     PMT30890
C *** PEM-2 MODIFICATIONS BY K. S. RAO                                  PMT30900
C     DECEMBER 1984                                                     PMT30910
C                                                                       PMT30920
C                                                                       PMT30930
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                  PMT30940
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),       PMT30950
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                 PMT30960
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                         PMT30970
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),              PMT30980
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),          PMT30990
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,                PMT31000
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                   PMT31010
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,                PMT31020
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,      PMT31030
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT31040
C                                                                       PMT31050
      COMMON/CSWOR/NWORST(25,25,5,2),CWORST(25,25,5,2)                  PMT31060
      COMMON/PARM1/NPOL,VD1,W1,VD2,W2                                   PMT31070
C                                                                       PMT31080
C                                                                       PMT31090
C     START DO-LOOP ON POLLUTANT SPECIES                                PMT31100
      DO 400 K=1,NPOL                                                   PMT31110
      WRITE(IWR,905) TT,ISCEN                                           PMT31120
      IF(NWDOPT.LE.1) GO TO 200                                         PMT31130
      WOUT=WD(ISCEN)*180./3.1415927                                     PMT31140
      WRITE(IWR,910) WOUT                                               PMT31150
C                                                                       PMT31160
  200 WRITE(IWR,920) K,(POLNAM(M,K),M=1,3)                              PMT31170
      WRITE(IWR,915)                                                    PMT31180
C                                                                       PMT31190
C     START DO-LOOP ON RECEPTOR GRID COLUMNS                            PMT31200
      DO 350 I=1,LX                                                     PMT31210
      XI=I                                                              PMT31220
      X= XSWC + (XI-0.5)*GRID                                           PMT31230
C                                                                       PMT31240
C     START DO-LOOP ON RECEPTOR GRID ROWS                               PMT31250
      DO 300 J=1,LY                                                     PMT31260
C                                                                       PMT31270
C     SUPPRESS PRINT IF THE HIGHEST CONCENTRATION IS INSIGNIFICANT      PMT31280
      IF(CWORST(I,J,1,K).LT.1.0) GO TO 300                              PMT31290
C                                                                       PMT31300
C     START DO-LOOP TO CONVERT FIVE HIGHEST CONTRIBUTIONS TO            PMT31310
C     PERCENTAGES OF TOTAL CONCENTRATION AT THE RECEPTOR                PMT31320
      DO 250 L=1,5                                                      PMT31330
      CWORST(I,J,L,K)=CWORST(I,J,L,K)*100./CONC(I,J,K)                  PMT31340
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  250 CONTINUE                                                          PMT31350
C     END LOOP ON FIVE HIGHEST CONTRIBUTIONS                            PMT31360
C                                                                       PMT31370
      YJ=J                                                              PMT31380
      Y= YSWC + (YJ-0.5)*GRID                                           PMT31390
      WRITE(IWR,925)I,J,X,Y,NWORST(I,J,1,K),CWORST(I,J,1,K),NWORST(I,J,2PMT31400
     1,K),CWORST(I,J,2,K),NWORST(I,J,3,K),CWORST(I,J,3,K),NWORST(I,J,4,KPMT31410
     2),CWORST(I,J,4,K),NWORST(I,J,5,K),CWORST(I,J,5,K),CONC(I,J,K),SDF(PMT31420
     3I,J,K)                                                            PMT31430
C                                                                       PMT31440
  300 CONTINUE                                                          PMT31450
C     END LOOP ON GRID ROWS                                             PMT31460
  350 CONTINUE                                                          PMT31470
C     END LOOP ON GRID COLUMNS                                          PMT31480
  400 CONTINUE                                                          PMT31490
C     END LOOP ON SPECIES                                               PMT31500
C                                                                       PMT31510
      RETURN                                                            PMT31520
C                                                                       PMT31530
  905 FORMAT(1H1,37X,'POLLUTION EPISODIC MODEL (PEM-2)'///4X,'OUTPUT:  'PMT31540
     1,20A4//4X,'LIST OF THE FIVE POINT SOURCES WHICH PRODUCE THE HIGHESPMT31550
     2T VALUES OF CONCENTRATION AND SURFACE DEPOSITION FLUX AT EACH RECEPMT31560
     3PTOR'//5X,'SCENARIO',14X,'  -  CONCENTRATION IN MICROGRAMS PER ', PMT31570
     4'CUBIC METER'/6X,'NUMBER: ',I2,16X,'SURFACE DEPOSITION FLUX IN MICPMT31580
     5ROGRAMS PER SQUARE METER PER HOUR'/)                              PMT31590
  910 FORMAT(6X,'WIND DIRECTION = ',F5.1,' DEG'/)                       PMT31600
  915 FORMAT(45X,'POINT SOURCE SEQUENCE NUMBER AND PERCENT'/            PMT31610
     115X,'COORDINATES',15X,'OF TOTAL CONCENTRATION AND SURFACE DEPOSITIPMT31620
     2ON FLUX',14X,'TOTAL',8X,'TOTAL SURFACE'/                          PMT31630
     3' COL ROW',4X,'X (KM)',4X,'Y (KM)',9X,'HIGHEST',6X,'SECOND',8X,   PMT31640
     4'THIRD',7X,'FOURTH',8X,'FIFTH',6X,'CONCENTRATION',3X,'DEPOSITION FPMT31650
     5LUX'/)                                                            PMT31660
  920 FORMAT(45X,'POLLUTANT-',I1,' :',3A4)                              PMT31670
  925 FORMAT(2(2X,I2),3X,F8.2,2X,F8.2,3X,5(3X,I3,F7.2),6X,F8.2,9X,F8.2) PMT31680
C                                                                       PMT31690
      END                                                               PMT31700
C
C                                                                       PMT31710
C                                                                       PMT31720
      SUBROUTINE SCENMX                                                 PMT31730
C                    SUBROUTINE SCENMX , PART OF PEM-2 (VERSION 84130). PMT31740
C                                                                       PMT31750
C                                                                       PMT31760
C  SUBROUTINE SCENMX LOCATES AND STORES THE COORDINATES, CONCENTRATION, PMT31770
C  AND SURFACE DEPOSITION FLUX AT THE RECEPTOR GRID POINTS RECORDING    PMT31780
C  THE HIGHEST CONCENTRATION AND SURFACE DEPOSITION FLUX OF EACH        PMT31790
C  POLLUTANT IN EACH SCENARIO (IF NTOPT=1) OR AVERAGING-PERIOD (IF      PMT31800
C  NTOPT>1).                                                            PMT31810
C                                                                       PMT31820
C  THE STORED VALUES ARE PRINTED BY SUBROUTINE MAXOUT AT THE END OF RUN.PMT31830
C                                                                       PMT31840
C                                                                       PMT31850
C *** PEM MODIFICATIONS BY M.M. STEVENS,                                PMT31860
C     NOAA-ATDL, P.O.BOX - E, OAK RIDGE, TN 37831                       PMT31870
C     DECEMBER 1982                                                     PMT31880
C                                                                       PMT31890
C                                                                       PMT31900
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                  PMT31910
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),       PMT31920
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                 PMT31930
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                         PMT31940
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),              PMT31950
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),          PMT31960
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,                PMT31970
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                   PMT31980
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,                PMT31990
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,      PMT32000
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT32010
C                                                                       PMT32020
      COMMON/MAX/XMX(24,4,2),YMX(24,4,2),ZMX(24,4,2),SMX(24,4,2)        PMT32030
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```
      COMMON/PARM1/NPOL,VD1,W1,VD2,W2                                   PMT32040
C                                                                       PMT32050
C                                                                       PMT32060
      IF(NTOPT.EQ.1) GO TO 120                                          PMT32070
      I= 1                                                              PMT32080
      GO TO 130                                                         PMT32090
120   I= ISCEN                                                          PMT32100
130   IF(NWDOPT.LE.1) GO TO 140                                         PMT32110
      J= IWDOPT                                                         PMT32120
      GO TO 150                                                         PMT32130
140   J= 1                                                              PMT32140
150   DO 400 K=1,NPOL                                                   PMT32150
      Z= 0.                                                             PMT32160
      DO 350 NX=1,LX                                                    PMT32170
      DO 350 NY=1,LY                                                    PMT32180
      IF(CONC(NX,NY,K).LT.Z) GO TO 350                                  PMT32190
      Z= CONC(NX,NY,K)                                                  PMT32200
      ZS=SDF(NX,NY,K)                                                   PMT32210
      ZX=NX                                                             PMT32220
      ZY=NY                                                             PMT32230
350   CONTINUE                                                          PMT32240
      ZMX(I,J,K)= Z                                                     PMT32250
      SMX(I,J,K)=ZS                                                     PMT32260
      XMX(I,J,K)= XSWC + (ZX - 0.5)*GRID                                PMT32270
      YMX(I,J,K)= YSWC + (ZY - 0.5)*GRID                                PMT32280
400   CONTINUE                                                          PMT32290
      RETURN                                                            PMT32300
      END                                                               PMT32310
C
C                                                                       PMT32320
C                                                                       PMT32330
      SUBROUTINE MAXOUT                                                 PMT32340
C                    SUBROUTINE MAXOUT , PART OF PEM-2 (VERSION 84130). PMT32350
C                                                                       PMT32360
C                                                                       PMT32370
C  SUBROUTINE MAXOUT PRINTS THE COORDINATES, CONCENTRATION, AND         PMT32380
C  SURFACE DEPOSITION FLUX AT THE RECEPTOR GRID POINTS RECORDING        PMT32390
C  THE HIGHEST CONCENTRATION OF EACH POLLUTANT IN EACH SCENARIO OR      PMT32400
C  AVERAGING PERIOD. THESE VALUES WERE SELECTED AND STORED BY SUB-      PMT32410
C  ROUTINE SCENMX.                                                      PMT32420
C                                                                       PMT32430
C                                                                       PMT32440
C                                                                       PMT32450
C *** PEM MODIFICATIONS AND FORMATS BY M.M. STEVENS,                    PMT32460
C     NOAA-ATDL, P.O.BOX E, OAK RIDGE, TN 37831                         PMT32470
C     DECEMBER 1982                                                     PMT32480
C *** PEM-2 MODIFICATIONS BY K. S. RAO                                  PMT32490
C     DECEMBER 1984                                                     PMT32500
C                                                                       PMT32510
C                                                                       PMT32520
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                  PMT32530
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),       PMT32540
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                 PMT32550
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                         PMT32560
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),              PMT32570
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),          PMT32580
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,                PMT32590
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                   PMT32600
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,                PMT32610
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,      PMT32620
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT32630
C                                                                       PMT32640
      COMMON/MAX/XMX(24,4,2),YMX(24,4,2),ZMX(24,4,2),SMX(24,4,2)        PMT32650
      COMMON/PARM1/NPOL,VD1,W1,VD2,W2                                   PMT32660
      DIMENSION ZC(2),ZS(2),AVD(2)                                      PMT32670
C                                                                       PMT32680
C   CHECK WHETHER SURF DEP FLUX WAS CALCULATED AND SET FLAG             PMT32690
      NREP=0                                                            PMT32700
      IF(VD1.GE.0.01 .OR. VD2.GE.0.01) GO TO 100                        PMT32710
      GO TO 110                                                         PMT32720
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  100 NREP=1                                                            PMT32730
      AVD(1)=A(1)*VD1*36.                                               PMT32740
      AVD(2)=A(2)*VD2*36.                                               PMT32750
C                                                                       PMT32760
  110 IF(NWDOPT.GT.1) GO TO 300                                         PMT32770
C                                                                       PMT32780
      J=1                                                               PMT32790
      N=1                                                               PMT32800
      IF(NTOPT.EQ.1) N=NSCEN                                            PMT32810
C   PRINT HIGHEST CONCENTRATIONS                                        PMT32820
      WRITE(IWR,900) TT                                                 PMT32830
      WRITE(IWR,902) (CALNAM(L,1),L=1,7)                                PMT32840
      IF(NPOL.EQ.2) WRITE(IWR,903) (CALNAM(L,2),L=1,7)                  PMT32850
      WRITE(IWR,910) (POLNAM(L,1),L=1,3)                                PMT32860
      IF(NPOL.EQ.2) WRITE(IWR,911) (POLNAM(L,2),L=1,3)                  PMT32870
      WRITE(IWR,912)                                                    PMT32880
      WRITE(IWR,915)                                                    PMT32890
      DO 200 I=1,N                                                      PMT32900
      DO 120 K=1,NPOL                                                   PMT32910
  120 ZC(K)= A(K) + B(K)*ZMX(I,1,K)                                     PMT32920
      WRITE(IWR,920)                                                    PMT32930
      WRITE(IWR,923) I,(XMX(I,1,K),YMX(I,1,K),ZMX(I,1,K),ZC(K),         PMT32940
     1 K=1,NPOL)                                                        PMT32950
  200 CONTINUE                                                          PMT32960
C                                                                       PMT32970
C   PRINT SURFACE DEPOSITION FLUX VALUES                                PMT32980
C   IF NO SURF DEP FLUX WAS CALCULATED, SKIP PRINT                      PMT32990
      IF(NREP.EQ.0) RETURN                                              PMT33000
      WRITE(IWR,900) TT                                                 PMT33010
      WRITE(IWR,932) (CALNAM(L,1),L=1,7)                                PMT33020
      IF(NPOL.EQ.2) WRITE(IWR,933) (CALNAM(L,2),L=1,7)                  PMT33030
      WRITE(IWR,910) (POLNAM(L,1),L=1,3)                                PMT33040
      IF(NPOL.EQ.2) WRITE(IWR,911) (POLNAM(L,2),L=1,3)                  PMT33050
      WRITE(IWR,942)                                                    PMT33060
      WRITE(IWR,915)                                                    PMT33070
      DO 250 I=1,N                                                      PMT33080
      DO 220 K=1,NPOL                                                   PMT33090
  220 ZS(K)= AVD(K) + B(K)*SMX(I,1,K)                                   PMT33100
      WRITE(IWR,920)                                                    PMT33110
      WRITE(IWR,923) I,(XMX(I,1,K),YMX(I,1,K),SMX(I,1,K),ZS(K),         PMT33120
     1 K=1,NPOL)                                                        PMT33130
  250 CONTINUE                                                          PMT33140
C                                                                       PMT33150
      RETURN                                                            PMT33160
C                                                                       PMT33170
C   PRINT FOR CASE OF NWDOPT>1  -  SUB-SCENARIOS                        PMT33180
  300 N=NSCEN                                                           PMT33190
C   PRINT HIGHEST CONCENTRATIONS                                        PMT33200
      DO 500 I=1,N                                                      PMT33210
      IF(((I-1)/8)*8.NE.I-1) GO TO 310                                  PMT33220
      WRITE(IWR,900) TT                                                 PMT33230
      WRITE(IWR,902) (CALNAM(L,1),L=1,7)                                PMT33240
      IF(NPOL.EQ.2) WRITE(IWR,903) (CALNAM(L,2),L=1,7)                  PMT33250
      WRITE(IWR,910) (POLNAM(L,1),L=1,3)                                PMT33260
      IF(NPOL.EQ.2) WRITE(IWR,911) (POLNAM(L,2),L=1,3)                  PMT33270
      WRITE(IWR,912)                                                    PMT33280
      WRITE(IWR,915)                                                    PMT33290
  310 WRITE(IWR,920)                                                    PMT33300
      DO 400 J=1,4                                                      PMT33310
      DO 320 K=1,NPOL                                                   PMT33320
  320 ZC(K)= A(K) + B(K)*ZMX(I,J,K)                                     PMT33330
      WRITE(IWR,925) I,J,(XMX(I,J,K),YMX(I,J,K),ZMX(I,J,K),ZC(K),       PMT33340
     1 K=1,NPOL)                                                        PMT33350
  400 CONTINUE                                                          PMT33360
  500 CONTINUE                                                          PMT33370
C                                                                       PMT33380
C   PRINT SURFACE DEPOSITION FLUX VALUES                                PMT33390
C   IF NO SURF DEP FLUX WAS CALCULATED, SKIP PRINT                      PMT33400
      IF(NREP.EQ.0) RETURN                                              PMT33410
      DO 600 I=1,N                                                      PMT33420
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```
      IF(((I-1)/8)*8.NE.I-1) GO TO 510                                  PMT33430
      WRITE(IWR,900) TT                                                 PMT33440
      WRITE(IWR,932) (CALNAM(L,1),L=1,7)                                PMT33450
      IF(NPOL.EQ.2) WRITE(IWR,933) (CALNAM(L,2),L=1,7)                  PMT33460
      WRITE(IWR,910) (POLNAM(L,1),L=1,3)                                PMT33470
      IF(NPOL.EQ.2) WRITE(IWR,911) (POLNAM(L,2),L=1,3)                  PMT33480
      WRITE(IWR,942)                                                    PMT33490
      WRITE(IWR,915)                                                    PMT33500
  510 WRITE(IWR,920)                                                    PMT33510
      DO 550 J=1,4                                                      PMT33520
      DO 520 K=1,NPOL                                                   PMT33530
  520 ZS(K)= AVD(K) + B(K)*SMX(I,J,K)                                   PMT33540
      WRITE(IWR,925) I,J,(XMX(I,J,K),YMX(I,J,K),SMX(I,J,K),ZS(K),       PMT33550
     1 K=1,NPOL)                                                        PMT33560
  550 CONTINUE                                                          PMT33570
  600 CONTINUE                                                          PMT33580
C                                                                       PMT33590
  700 RETURN                                                            PMT33600
C                                                                       PMT33610
  900 FORMAT(1H1,37X,'POLLUTION EPISODIC MODEL (PEM-2)'///4X,'OUTPUT:  'PMT33620
     1,20A4//)                                                          PMT33630
  902 FORMAT(4X,'HIGHEST PREDICTED CONCENTRATION OF EACH POLLUTANT FOR EPMT33640
     1ACH SCENARIO OR AVERAGING PERIOD'//4X,'UNCALIBRATED CONCENTRATION PMT33650
     2IN MICROGRAMS PER CUBIC METER  -  CALIBRATION, POLLUTANT-1: ',7A4)PMT33660
  903 FORMAT(65X,'CALIBRATION, POLLUTANT-2: ',7A4)                      PMT33670
  910 FORMAT(//40X,'POLLUTANT-1: ',3A4)                                 PMT33680
  911 FORMAT(1H+,93X,'POLLUTANT-2: ',3A4)                               PMT33690
  912 FORMAT(/' SCENARIO  WIND DIRECTION',7X,'COORDINATES',14X,         PMT33700
     1'CONCENTRATION',16X,'COORDINATES',14X,'CONCENTRATION')            PMT33710
  915 FORMAT(2X,'NUMBER',4X,'SUB-SCENARIO',6X,'X(KM)',5X,'Y(KM)',6X,    PMT33720
     1'UNCALIBRATED',4X,'CALIBRATED',7X,'X(KM)',5X,'Y(KM)',6X,          PMT33730
     2'UNCALIBRATED',4X,'CALIBRATED'/)                                  PMT33740
  920 FORMAT(1X)                                                        PMT33750
  923 FORMAT(4X,I2,21X,F9.2,1X,F9.2,5X,F11.4,4X,F11.4,4X,F9.2,1X,       PMT33760
     1F9.2,5X,F11.4,4X,F11.4)                                           PMT33770
  925 FORMAT(4X,I2,11X,I2,8X,F9.2,1X,F9.2,5X,F11.4,4X,F11.4,4X,F9.2,1X, PMT33780
     1F9.2,5X,F11.4,4X,F11.4)                                           PMT33790
  932 FORMAT(4X,'HIGHEST PREDICTED SURFACE DEPOSITION FLUX OF EACH POLLUPMT33800
     1TANT FOR EACH SCENARIO OR AVERAGING PERIOD'//4X,'UNCALIBRATED VALUPMT33810
     2ES IN MICROGRAMS PER SQUARE METER PER HOUR  -  CALIBRATION, POLLUTPMT33820
     3ANT-1: ',7A4)                                                     PMT33830
  933 FORMAT(68X,'CALIBRATION, POLLUTANT-2: ',7A4)                      PMT33840
  942 FORMAT(/' SCENARIO  WIND DIRECTION',7X,'COORDINATES',9X,          PMT33850
     1'SURFACE DEPOSITION FLUX',11X,'COORDINATES',9X,'SURFACE DEPOSITIONPMT33860
     2 FLUX')                                                           PMT33870
      END                                                               PMT33880
C
C                                                                       PMT33890
C                                                                       PMT33900
      SUBROUTINE RISE                                                   PMT33910
C                    SUBROUTINE RISE   , PART OF PEM-2 (VERSION 84130). PMT33920
C                                                                       PMT33930
C                                                                       PMT33940
C  SUBROUTINE RISE CALCULATES PLUME RISE VIA THE STANDARD EQUATIONS     PMT33950
C    OF BRIGGS (1971,1969) IF NPRISE=0. IF NPRISE=1 OPTION IS SELECTED, PMT33960
C    THE NEW PLUME RISE EQUATIONS OF BRIGGS (1984,1975) ARE USED FOR THEPMT33970
C    BUOYANCY-DOMINATED PEAK PLUME RISE IN UNSTABLE/NEUTRAL CONDITIONS. PMT33980
C    IF IRISE=1, THE DISTANCE-DEPENDENT EFFECTIVE SOURCE HEIGHT (ESH(1))PMT33990
C    IS RETURNED. IF IRISE=2, MAXIMUM EFFECTIVE SOURCE HEIGHT (ESH(2) ISPMT34000
C    RETURNED. RISE IS CALLED ONLY ONCE PER SOURCE PER SCENARIO WITH    PMT34010
C    IRISE=2. IT IS CALLED WITH IRISE=1 WHENEVER THE DOWNWIND DISTANCE  PMT34020
C    (DIST) IS LESS THAN THE DISTANCE TO MAXIMUM PLUME RISE (PEAK).     PMT34030
C    SUBROUTINE RISE IS CALLED IN THE MAIN PROGRAM, AND IN SUBROUTINES  PMT34040
C    QZCAL AND AUTGRD.                                                  PMT34050
C                                                                       PMT34060
C                                                                       PMT34070
C     PEM-2 MODIFICATIONS: APRIL 1984                                   PMT34080
C     K.SHANKAR RAO                                                     PMT34090
C     NOAA-ATDL, P.O. BOX-E                                             PMT34100
C     OAK RIDGE, TENN 37831                                             PMT34110
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C                                                                       PMT34120
C                                                                       PMT34130
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                  PMT34140
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),       PMT34150
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                 PMT34160
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                         PMT34170
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),              PMT34180
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),          PMT34190
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,                PMT34200
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                   PMT34210
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,                PMT34220
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,      PMT34230
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT34240
C                                                                       PMT34250
      IDWN=1                                                            PMT34260
      IF(IRISE.EQ.1) GO TO 200                                          PMT34270
C                                                                       PMT34280
C     IRISE=2: DETERMINE WHETHER THE PLUME IS DOMINATED BY MOMENTUM OR  PMT34290
C     BUOYANCY, AND CALCULATE OPTIONAL STACK-TIP DOWNWASH CORRECTION,   PMT34300
C     MAXIMUM EFFECTIVE SOURCE HEIGHT, AND VALUES OF CONSTANT FACTORS INPMT34310
C     RELATED DISTANCE-DEPENDENT PLUME RISE EQUATIONS.                  PMT34320
      HPRIME=HP(IPS)                                                    PMT34330
      IF(NSTDWN.EQ.1) GO TO 10                                          PMT34340
C                                                                       PMT34350
C     NSTDWN=0; DOWNWASH CORRECTION.                                    PMT34360
      RATV=VP(IPS)*UINV                                                 PMT34370
      IF(RATV.GE.1.5) GO TO 10                                          PMT34380
      DWNWSH=2.0*(1.5-RATV)*DP(IPS)                                     PMT34390
      IDWN=3                                                            PMT34400
      IF(DWNWSH.GE.HP(IPS)) DWNWSH=HP(IPS)                              PMT34410
      HPRIME=HP(IPS)-DWNWSH                                             PMT34420
C                                                                       PMT34430
C     DETERMINE IF PLUME IS MOMENTUM-DOMINATED (IBUOY=0)                PMT34440
C                        OR BUOYANCY-DOMINATED (IBUOY=1),               PMT34450
C     USING THE BUOYANCY - MOMENTUM CROSSOVER TECHNIQUES.               PMT34460
   10 IBUOY=1                                                           PMT34470
      CVD3=3.0*VP(IPS)*DP(IPS)                                          PMT34480
      DELHUM=CVD3*UINV                                                  PMT34490
      IF(ISC.LT.5) GO TO 20                                             PMT34500
C     STABILITY CLASSES E AND F.                                        PMT34510
      IF(ISC.EQ.6) GO TO 15                                             PMT34520
      BRIGC=115.28                                                      PMT34530
      DIF=ABS(DTDZ(1)-0.02)                                             PMT34540
      GO TO 16                                                          PMT34550
   15 BRIGC= 87.14                                                      PMT34560
      DIF=ABS(DTDZ(2)-0.035)                                            PMT34570
   16 IF(DIF.GT.0.001) BRIGC=16.30/SQRT(DTDZ(ISC-4))                    PMT34580
      IF(VP(IPS).GT.BRIGC*(TP(IPS)-TA(ISCEN))/SQRT(TA(ISCEN))) IBUOY=0  PMT34590
      IF(IBUOY.EQ.0) GO TO 90                                           PMT34600
      GO TO 60                                                          PMT34610
   20 IF(NPRISE.EQ.1) GO TO 50                                          PMT34620
C                                                                       PMT34630
C     NPRISE=0: STANDARD (DEFAULT) PLUME RISE EQS. STABILITY CLASSES A-DPMT34640
      IF(EFF.GE.55.) GO TO 30                                           PMT34650
      AF=21.425                                                         PMT34660
      BF=0.75                                                           PMT34670
      GO TO 40                                                          PMT34680
   30 AF=38.710                                                         PMT34690
      BF=0.6                                                            PMT34700
   40 IF(CVD3.GT.AF*EFF**BF) IBUOY=0                                    PMT34710
      IF(IBUOY.EQ.0) GO TO 80                                           PMT34720
      IF(EFF.LT.55.) XS=49.*(EFF**0.625)                                PMT34730
      IF(EFF.GE.55.) XS=119.*(EFF**0.4)                                 PMT34740
      GO TO 60                                                          PMT34750
C                                                                       PMT34760
C     NPRISE=1: NEW (OPTIONAL) PLUME RISE EQS. STABILITY CLASSES A-D.   PMT34770
   50 DELH1=30.*(EFF*UINV)**0.6                                         PMT34780
      FOU3=EFF*(UINV**3)                                                PMT34790
      TERMH2=HPRIME+200.*FOU3                                           PMT34800
      DELH2=24.*(FOU3**0.6)*(TERMH2**0.4)                               PMT34810
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C     SELECT THE LOWER VALUE GIVEN BY THE TWO BUOYANCY RISE EQUATIONS.  PMT34820
      DELTAH=DELH1                                                      PMT34830
      IF(DELH2.LT.DELH1) DELTAH=DELH2                                   PMT34840
C     SELECT THE HIGHER VALUE GIVEN BY THE MOMENTUM RISE AND DELTAH.    PMT34850
      IF(DELHUM.GT.DELTAH) IBUOY=0                                      PMT34860
      IF(IBUOY.EQ.0) GO TO 80                                           PMT34870
      IF(DELH2.GE.DELH1) XS=81.19*(EFF**0.4)/(UINV**0.6)                PMT34880
      IF(DELH2.LT.DELH1) XS=58.09*(FOU3**0.4)*(TERMH2**0.6)             PMT34890
C                                                                       PMT34900
   60 CTB= 1.6*UINV*EFF**0.333333                                       PMT34910
      IF(ISC.GE.5) GO TO 70                                             PMT34920
      IF(NPRISE.EQ.1) GO TO 100                                         PMT34930
C                                                                       PMT34940
C  PEAK PLUME RISE: BUOYANCY-DOMINATED PLUME, UNSTABLE AIR (A-D).       PMT34950
      DELTAH= CTB*XS**0.666667                                          PMT34960
      GO TO 100                                                         PMT34970
C                                                                       PMT34980
C  PEAK PLUME RISE: BUOYANCY-DOMINATED PLUME, STABLE AIR (E,F).         PMT34990
   70 DELTAH= 2.6*(EFF*UINV*TA(ISCEN)/(9.8*DTDZ(ISC-4)))**0.333333      PMT35000
      GO TO 100                                                         PMT35010
C                                                                       PMT35020
C  PEAK PLUME RISE: MOMENTUM-DOMINATED PLUME, UNSTABLE AIR (A-D).       PMT35030
   80 CTMU= 1.89*(VP(IPS)*VP(IPS)*DP(IPS)*UINV/(VP(IPS)+3./UINV))**0.666PMT35040
     1667                                                               PMT35050
      DELTAH= DELHUM                                                    PMT35060
      GO TO 100                                                         PMT35070
C                                                                       PMT35080
C  PEAK PLUME RISE: MOMENTUM-DOMINATED PLUME, STABLE AIR (E,F).         PMT35090
C                                                                       PMT35100
   90 FACT=UINV*TA(ISCEN)/TP(IPS)                                       PMT35110
      DELTAH= 1.5*(0.5*VP(IPS)*DP(IPS))**0.666667*FACT**0.333333        PMT35120
     1 *(TA(ISCEN)/(DTDZ(ISC-4)*9.8))**0.166667                         PMT35130
      IF(DELHUM.LT.DELTAH) DELTAH=DELHUM                                PMT35140
C                                                                       PMT35150
  100 ESH(2)= HPRIME + DELTAH                                           PMT35160
      RETURN                                                            PMT35170
C                                                                       PMT35180
  200 IF(IBUOY.EQ.0) GO TO 210                                          PMT35190
C                                                                       PMT35200
C  DISTANCE-DEPENDENT PLUME RISE: BUOYANCY-DOMINATED PLUME,             PMT35210
C    ANY STABILITY (A-F).                                               PMT35220
      DELTAH= CTB*(DIST*1000.)**0.666667                                PMT35230
      ESH(1)=DELTAH + HPRIME                                            PMT35231
      IF(ESH(1).GT.ESH(2)) ESH(1)=ESH(2)                                PMT35240
      RETURN                                                            PMT35250
C                                                                       PMT35260
C  DISTANCE-DEPENDENT PLUME RISE: MOMENTUM-DOMINATED PLUME,             PMT35270
C    UNSTABLE AIR (A-D).                                                PMT35280
  210 IF(ISC.GE.5) GO TO 220                                            PMT35290
      DELTAH= CTMU*(DIST*1000.)**0.333333                               PMT35300
      ESH(1)=DELTAH + HPRIME                                            PMT35301
      IF(ESH(1).GT.ESH(2)) ESH(1)=ESH(2)                                PMT35310
      RETURN                                                            PMT35320
C                                                                       PMT35330
C  THERE IS NO DISTANCE-DEPENDENT PLUME RISE GIVEN FOR A                PMT35340
C    MOMENTUM-DOMINATED PLUME IN STABLE AIR. DISTANCE TO MAXIMUM PLUME  PMT35350
C    RISE FOR THIS SITUATION IS SET EQUAL TO ZERO IN THE MAIN PROGRAM,  PMT35360
C    SO THE MAXIMUM HEIGHT, ESH(2), IS USED AT ALL DISTANCES.           PMT35370
  220 ESH(1)=ESH(2)                                                     PMT35380
      RETURN                                                            PMT35390
C                                                                       PMT35400
      END                                                               PMT35410
C
C                                                                       PMT35420
C                                                                       PMT35430
C                                                                       PMT35440
      SUBROUTINE AUTGRD                                                 PMT35450
C                    SUBROUTINE AUTGRD , PART OF PEM-2 (VERSION 84130). PMT35460
C                                                                       PMT35470
C                                                                       PMT35480
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C   SUBROUTINE AUTGRID CALCULATES THE FIVE PARAMETERS DEFINING THE      PMT35490
C     RECEPTOR GRID (XSWC,YSWC,LX,LY,GRID) WHEN THE AUTOMATIC GRID      PMT35500
C     OPTION IS USED. THIS IS DONE BY SETTING GRID=0.0 IN THE INPUT     PMT35510
C     DATA. GRID PARAMETERS WILL BE CHOSEN FOR EACH SCENARIO SO AS      PMT35520
C     TO INSURE GOOD COVERAGE BY RECEPTORS NEAR THE POINT OF            PMT35530
C     MAXIMUM CONCENTRATION.  THIS POINT IS DETERMINED USING GAUSSIAN   PMT35540
C     PLUME ALGORITHMS WITHOUT POLLUTANT REMOVAL MECHANISMS.  THIS      PMT35550
C     POINT IS THEREFORE ONLY APPROXIMATE FOR PROBLEMS WHICH INCLUDE    PMT35560
C     DEPOSITION, SEDIMENTATION, AND CHEMICAL DECAY/TRANSFORMATION.     PMT35570
C     THE OPTIMUM RECEPTOR GRID IN THIS CASE SHOULD BE DETERMINED BY    PMT35580
C     TRIAL AND ERROR, USING THE RECEPTOR GRID DEFINED BY AUTGRD AS     PMT35590
C     THE FIRST APPROXIMATION.                                          PMT35600
C     NOTE THAT THE AUTOMATIC GRID OPTION CANNOT BE USED WHEN NTOPT>1 . PMT35610
C                                                                       PMT35620
C                                                                       PMT35630
C *** PEM-2 MODIFICATIONS BY K. SHANKAR RAO,                            PMT35640
C     NOAA-ATDL, OAK RIDGE, TENN.                                       PMT35650
C     APRIL 1984                                                        PMT35660
C                                                                       PMT35670
C                                                                       PMT35680
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                  PMT35690
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),       PMT35700
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                 PMT35710
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                         PMT35720
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),              PMT35730
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),          PMT35740
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,                PMT35750
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                   PMT35760
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,                PMT35770
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,      PMT35780
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT35790
C                                                                       PMT35800
      COMMON/PARM2A/HAS,KSC,AA,BA,CA                                    PMT35810
      COMMON/PARM7A/HA,P1(6)                                            PMT35820
      DIMENSION XCRNR(4),YCRNR(4),HL(2),DL(2),XTM(2)                    PMT35830
C                                                                       PMT35840
C                                                                       PMT35850
      EPS=.005                                                          PMT35860
      NSTOP=100                                                         PMT35870
      AART2=SQRT(2.)*AA                                                 PMT35880
C                                                                       PMT35890
      E= 1.570796 -WVEC                                                 PMT35900
      SINEE= SIN(E)                                                     PMT35910
      COSNE= COS(E)                                                     PMT35920
      GX1= XP(1)*COSNE  + YP(1)*SINEE                                   PMT35930
      GX2= GX1                                                          PMT35940
      GY1= YP(1)*COSNE  - XP(1)*SINEE                                   PMT35950
      GY2= GY1                                                          PMT35960
      GX1=GX1+5.                                                        PMT35970
      GY1=GY1+5.                                                        PMT35980
      DO 200 I=1,NPS                                                    PMT35990
      XT= XP(I)*COSNE  + YP(I)*SINEE                                    PMT36000
      YT= YP(I)*COSNE  - XP(I)*SINEE                                    PMT36010
C                                                                       PMT36020
      UINV = 1./WS(ISCEN)                                               PMT36030
      IF(NWPOPT.EQ.1) GO TO 165                                         PMT36040
      IF(HP(I).GT.10.) UINV = UINV*((10./HP(I))**P(ISC))                PMT36050
      GO TO 166                                                         PMT36060
  165 IF(HP(I).GT.HA) UINV = UINV*((HA/HP(I)))**P1(ISC)                 PMT36070
  166 EFF= 2.45*VP(I)*DP(I)*DP(I)*(TP(I)-TA(ISCEN))/TP(I)               PMT36080
C                                                                       PMT36090
      HL(1)= HP(I)                                                      PMT36100
      XSTAR1=HL(1)/AART2                                                PMT36110
      CALL ROOT(XCMAX1,XSTAR1,EPS,NSTOP,IER)                            PMT36120
      DL(1)=.001*XCMAX1                                                 PMT36130
C                                                                       PMT36140
      IPS=I                                                             PMT36150
      IRISE=2                                                           PMT36160
      CALL RISE                                                         PMT36170
      HL(2)=ESH(2)                                                      PMT36180
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      XSTAR2=HL(2)/AART2                                                PMT36190
      CALL ROOT(XCMAX2,XSTAR2,EPS,NSTOP,IER)                            PMT36200
      DL(2)=.001*XCMAX2                                                 PMT36210
C                                                                       PMT36220
      XTM(1)= XT + DL(1)                                                PMT36230
      XTM(2)= XT + DL(2)                                                PMT36240
      IF(XTM(2).GT.GX2) GX2= XTM(2)                                     PMT36250
      IF(XTM(1).LT.GX1) GX1= XTM(1)                                     PMT36260
      IF(YT.GT.GY2)     GY2= YT                                         PMT36270
      IF(YT.LT.GY1)     GY1= YT                                         PMT36280
200   CONTINUE                                                          PMT36290
      XCRNR(1)= GX1                                                     PMT36300
      XCRNR(2)= GX2                                                     PMT36310
      XCRNR(3)= GX2                                                     PMT36320
      XCRNR(4)= GX1                                                     PMT36330
      YCRNR(1)= GY1                                                     PMT36340
      YCRNR(2)= GY1                                                     PMT36350
      YCRNR(3)= GY2                                                     PMT36360
      YCRNR(4)= GY2                                                     PMT36370
      DO 300 J=1,4                                                      PMT36380
      XCRNRT= XCRNR(J)                                                  PMT36390
      XCRNR(J)= XCRNR(J)*COSNE  - YCRNR(J)*SINEE                        PMT36400
300   YCRNR(J)= YCRNR(J)*COSNE + XCRNRT*SINEE                           PMT36410
      XSWC= XCRNR(1)                                                    PMT36420
      XNEC= XSWC                                                        PMT36430
      YSWC= YCRNR(1)                                                    PMT36440
      YNEC= YSWC                                                        PMT36450
      DO 400 I=2,4                                                      PMT36460
      IF(XCRNR(I).GT.XNEC) XNEC= XCRNR(I)                               PMT36470
      IF(XCRNR(I).LT.XSWC) XSWC= XCRNR(I)                               PMT36480
      IF(YCRNR(I).GT.YNEC) YNEC= YCRNR(I)                               PMT36490
400   IF(YCRNR(I).LT.YSWC) YSWC= YCRNR(I)                               PMT36500
      XT= XNEC - XSWC                                                   PMT36510
      YT= YNEC - YSWC                                                   PMT36520
      DMAX= XT                                                          PMT36530
      IF(YT.GT.XT) DMAX= YT                                             PMT36540
      IF(DMAX.LT.10.) GO TO 500                                         PMT36550
      IF(XT.GT.YT) GO TO 420                                            PMT36560
      LY=  50                                                           PMT36570
      GRID= YT/50.                                                      PMT36580
      LX= XT/GRID                                                       PMT36590
      IF(LX.LT.50) LX= LX+1                                             PMT36600
      GO TO 600                                                         PMT36610
420   LX= 50                                                            PMT36620
      GRID= XT/50.                                                      PMT36630
      LY= YT/GRID                                                       PMT36640
      IF(LY.LT.50) LY=LY+1                                              PMT36650
      GO TO 600                                                         PMT36660
500   IF(DMAX.LT.5.) GO TO 540                                          PMT36670
      GRID= 0.2                                                         PMT36680
      LX= XT/GRID                                                       PMT36690
      LY= YT/GRID                                                       PMT36700
      IF(LX.LT.50) LX=LX+1                                              PMT36710
      IF(LY.LT.50) LY=LY+1                                              PMT36720
      GO TO 600                                                         PMT36730
540   IF(DMAX.LT.0.25) GO TO 580                                        PMT36740
      IF(XT.GT.YT) GO TO 560                                            PMT36750
      LY= 25                                                            PMT36760
      GRID= YT/25.                                                      PMT36770
      LX= XT/GRID                                                       PMT36780
      IF(LX.LT.25) LX=LX+1                                              PMT36790
      GO TO 600                                                         PMT36800
560   LX= 25                                                            PMT36810
      GRID= XT/25.                                                      PMT36820
      LY= YT/GRID                                                       PMT36830
      IF(LY.LT.25) LY=LY+1                                              PMT36840
      GO TO 600                                                         PMT36850
580   GRID= 0.01                                                        PMT36860
      LX= XT/GRID                                                       PMT36870
      LY= YT/GRID                                                       PMT36880
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      IF(LX.LT.25) LX=LX+1                                              PMT36890
      IF(LY.LT.25) LY=LY+1                                              PMT36900
600   XSWC= XSWC - 0.5*GRID                                             PMT36910
      YSWC= YSWC - 0.5*GRID                                             PMT36920
      IF(NCSOPT.LT.1.OR.(LX.LE.25.AND.LY.LE.25)) GO TO 700              PMT36930
      XL=LX                                                             PMT36940
      YL=LY                                                             PMT36950
      IF(LX.GT.LY) GO TO 640                                            PMT36960
      DELG= YL/25.                                                      PMT36970
      LY=25                                                             PMT36980
      GRID= GRID*DELG                                                   PMT36990
      LX= XL/DELG                                                       PMT37000
      IF(LX.LT.25) LX=LX+1                                              PMT37010
      GO TO 700                                                         PMT37020
640   DELG= XL/25.                                                      PMT37030
      LX=25                                                             PMT37040
      GRID= GRID*DELG                                                   PMT37050
      LY= YL/DELG + 1.                                                  PMT37060
700   CONTINUE                                                          PMT37070
      WRITE(IWR,900)TT,ISCEN,IWDOPT                                     PMT37080
      XRSWC=XSWC+0.5*GRID                                               PMT37090
      YRSWC=YSWC+0.5*GRID                                               PMT37100
      WRITE(IWR,905)LX,LY,GRID,XRSWC,YRSWC                              PMT37110
  900 FORMAT(1H1,37X,'POLLUTION EPISODIC MODEL (PEM-2)'///4X,'OUTPUT:  'PMT37120
     1,20A4//4X,'AUTOMATICALLY GENERATED RECEPTOR GRID PARAMETERS FOR SCPMT37130
     2ENARIO ',I2,'  (WIND DIRECTION SUB-SCENARIO ',I2,')'//)           PMT37140
905   FORMAT(4X,'RECEPTOR GRID CONSISTS OF ',I2,' COLUMNS AND ',I2,' ROWPMT37150
     1S OF SPACING =',F7.4,' KM'//4X,'SOUTHWEST CORNER OF GRID =',F8.3, PMT37160
     2' KM WEST,',F8.3,' KM SOUTH'/)                                    PMT37170
      RETURN                                                            PMT37180
      END                                                               PMT37190
C
C                                                                       PMT37200
C                                                                       PMT37210
      SUBROUTINE FUNR(X,R,FX,FPRIMX)                                    PMT37220
C                    SUBROUTINE FUNR , PART OF PEM-2 (VERSION 84130).  PMT37230
C                                                                       PMT37240
C                                                                       PMT37250
C     FUNR IS THE EXTERNAL SUBROUTINE CALLED IN SUBROUTINE ROOT.        PMT37260
C     FOR ANY GIVEN X, THIS SUBROUTINE DEFINES THE FUNCTION, F(X), AND  PMT37270
C     ITS FIRST DERIVATIVE WITH RESPECT TO X, FPRIM(X).                 PMT37280
C     THESE FUNCTIONS ARE OF THE FORM: F(X)=P(X)*Q(X)-R, AND            PMT37290
C     FPRIM(X)=P(X)*DQDX(X)+Q(X)*DPDX(X)                                PMT37300
C                                                                       PMT37310
C                                                                       PMT37320
C     PEM-2 PROGRAM DEVELOPMENT: JANUARY 1984                           PMT37330
C     K. SHANKAR RAO                                                    PMT37340
C     NOAA-ATDL, P.O. BOX-E                                             PMT37350
C     OAK RIDGE, TENN 37831                                             PMT37360
C                                                                       PMT37370
C                                                                       PMT37380
      COMMON/PARM2A/HAS,KSC,AA,BA,CA                                    PMT37390
C                                                                       PMT37400
C     STABILITY CLASS C                                                 PMT37410
      IF(KSC.NE.3) GO TO 10                                             PMT37420
      PX=X*X                                                            PMT37430
      DX=1.+.0004*X                                                     PMT37440
      QX=(1.+.0003*X)/DX                                                PMT37450
      DPDX=2.*X                                                         PMT37460
      DQDX=-.0001/(DX*DX)                                               PMT37470
      GO TO 25                                                          PMT37480
C                                                                       PMT37490
C                                                                       PMT37500
   10 DX=1.+BA*X                                                        PMT37510
      IF(KSC.GT.3) GO TO 15                                             PMT37520
C                                                                       PMT37530
C     STABILITY CLASSES A AND B                                         PMT37540
      PX=0.5*X*X*DX                                                     PMT37550
      DPDX=X*(1.5*BA*X+1.)                                              PMT37560
      GO TO 20                                                          PMT37570
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C     STABILITY CLASSES D,E, AND F                                      PMT37580
   15 PX=0.5*X*X/DX                                                     PMT37590
      DPDX=0.5*X*(1.+DX)/(DX*DX)                                        PMT37600
C                                                                       PMT37610
C     ALL STABILITY CLASSES EXCEPT C                                    PMT37620
   20 TX1=1.+0.5*BA*X                                                   PMT37630
      TX2=1.+.0002*X                                                    PMT37640
      TX3=1.+.0004*X                                                    PMT37650
      QX=1.+DX*TX2/(TX1*TX3)                                            PMT37660
      DQDX=(-.0002*DX*TX1+0.5*BA*TX2*TX3)/((TX1*TX3)**2)                PMT37670
C     ALL STABILITY CLASSES                                             PMT37680
C                                                                       PMT37690
   25 FX=PX*QX-R                                                        PMT37700
      FPRIMX=PX*DQDX+QX*DPDX                                            PMT37710
C                                                                       PMT37720
      RETURN                                                            PMT37730
      END                                                               PMT37740
C
C                                                                       PMT37750
C                                                                       PMT37760
      SUBROUTINE ROOT(X,XSTAR,EPS,NSTOP,IER)                            PMT37770
C                        SUBROUTINE ROOT , PART OF PEM-2 (VERSION 84130). PMT37780
C                                                                       PMT37790
C                                                                       PMT37800
C     THIS SUBROUTINE FINDS THE ROOT OF A POLYNOMIAL EQUATION           PMT37810
C     F(X) = 0, USING THE NEWTON-RAPHSON ITERATION METHOD.              PMT37820
C     THIS SUBROUTINE IS CALLED IN SUBROUTINE AUTGRD TO                 PMT37830
C     DETERMINE THE DOWNWIND DISTANCE TO MAXIMUM GROUND-LEVEL           PMT37840
C     CONCENTRATION FROM AN ELEVATED POINT-SOURCE PLUME.                PMT37850
C                                                                       PMT37860
C     X = ROOT OF EQUATION F(X)=0. (OUTPUT)                             PMT37870
C     XSTAR = INITIAL GUESS OF VALUE OF X (INPUT)                       PMT37880
C     EPS = UPPER BOUND OF ERROR IN X (INPUT)                           PMT37890
C     NSTOP = MAXIMUM NO.OF ITERATION STEPS (INPUT)                     PMT37900
C     IER = ERROR MESSAGE (OUTPUT)                                      PMT37910
C         = 0  NO ERROR                                                 PMT37920
C         = 1  NO CONVERGENCE AFTER NSTOP ITERATIONS                    PMT37930
C         = 2  FPRIM GOES TO ZERO AT SOME ITERATION STEP                PMT37940
C                                                                       PMT37950
C     PEM-2 PROGRAM DEVELOPMENT: JANUARY 1984                           PMT37960
C     K. SHANKAR RAO                                                    PMT37970
C     NOAA-ATDL, P.O. BOX-E                                             PMT37980
C     OAK RIDGE, TENN 37831                                             PMT37990
C                                                                       PMT38000
C                                                                       PMT38010
      COMMON/PARM2A/HAS,KSC,AA,BA,CA                                    PMT38020
C                                                                       PMT38030
C     INITIALIZATION                                                    PMT38040
      IER=0                                                             PMT38050
      X=XSTAR                                                           PMT38060
      R=XSTAR*XSTAR                                                     PMT38070
      XO=X                                                              PMT38080
      CALL FUNR(XO,R,F,FPRIM)                                           PMT38090
      XOF=100.*EPS                                                      PMT38100
C                                                                       PMT38110
C     START ITERATION LOOP                                              PMT38120
      DO 16 I=1,NSTOP                                                   PMT38130
      IF(F) 11,16,11                                                    PMT38140
C                                                                       PMT38150
C     EQUATION IS NOT SATISFIED BY X                                    PMT38160
   11 IF(FPRIM) 12,18,12                                                PMT38170
C                                                                       PMT38180
C     ITERATION IS IMPOSSIBLE                                           PMT38190
   12 DX=F/FPRIM                                                        PMT38200
      X=X-DX                                                            PMT38210
      XO=X                                                              PMT38220
      CALL FUNR(XO,R,F,FPRIM)                                           PMT38230
C                                                                       PMT38240
C     TEST ON SATISFACTORY ACCURACY                                     PMT38250
      XO=EPS                                                            PMT38260
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      XABS=ABS(X)                                                       PMT38270
      IF(XABS-1.) 14,14,13                                              PMT38280
   13 XO=XO*XABS                                                        PMT38290
   14 IF(ABS(DX)-XO) 15,15,16                                           PMT38300
   15 IF(ABS(F)-XOF) 17,17,16                                           PMT38310
   16 CONTINUE                                                          PMT38320
C     END ITERATION LOOP                                                PMT38330
C                                                                       PMT38340
C     NO CONVERGENCE AFTER NSTOP ITERATION STEPS ERROR RETURN           PMT38350
      IER=1                                                             PMT38360
   17 RETURN                                                            PMT38370
C                                                                       PMT38380
C     ERROR RETURN IN CASE OF ZERO DENOMINATOR                          PMT38390
   18 IER=2                                                             PMT38400
      RETURN                                                            PMT38410
      END                                                               PMT38420
C
C                                                                       PMT38430
C                                                                       PMT38440
      BLOCK DATA                                                        PMT38450
C                          BLOCK DATA , PART OF PEM-2 (VERSION 84130).  PMT38460
C                                                                       PMT38470
C                                                                       PMT38480
C                                                                       PMT38490
C     THIS SUBPROGRAM INITIALIZES VARIABLES IN COMMON/PEMCOM/           PMT38500
C                                                                       PMT38510
C *** PEM MODIFICATIONS BY M.M.STEVENS,                                 PMT38520
C     NOAA-ATDL, P.O.BOX-E, OAK RIDGE, TENN 37831                       PMT38530
C     DECEMBER 1982                                                     PMT38540
C *** PEM-2 MODIFICATIONS BY K. SHANKAR RAO,                            PMT38550
C     DECEMBER 1983                                                     PMT38560
C                                                                       PMT38570
C                                                                       PMT38580
      COMMON/PEMCOM/CONC(50,50,2),SDF(50,50,2),TT(20),                  PMT38590
     1 XP(300),YP(300),EP(300,2),HP(300),DP(300),VP(300),TP(300),       PMT38600
     2 XA(50),YA(50),EA(50,2),SIZE(50),                                 PMT38610
     3 WD(24),WS(24),TA(24),HMIX(24),DTDZI(24),                         PMT38620
     4 AZ(6),BZ(6),CZ(6),P(6),SCLAB(6),DTDZ(2),SECTAN(16),              PMT38630
     5 XSWC,YSWC,GRID,LX,LY,A(2),B(2),POLNAM(3,2),CALNAM(7,2),          PMT38640
     6 ITA,IRD,IWR,IDSK,D80,D47,D8047,DIST,DELTA,HPRIME,                PMT38650
     7 ESH(2),PEAK,IBUOY,IRISE,IDWN,EFF,XS,UINV,WVEC,                   PMT38660
     8 NAS,NPS,INDEX,IGRID,IAV,ISCEN,IWDOPT,IWD,ISC,IPS,                PMT38670
     9 NTOPT,NWDOPT,NWSOPT,NWPOPT,NSCEN,NLIST,NARRAY,NTAPE,NCSOPT,      PMT38680
     * NMAX,NSTDWN,NPRISE,NINPEN,INTER,NPRINT,NGPR,NBID                 PMT38690
C                                                                       PMT38700
C                                                                       PMT38710
      DATA INDEX,NAS,NPS/0,0,0/                                         PMT38720
      DATA ITA,IRD,IWR,IDSK/1,5,6,8/                                    PMT38730
      DATA SCLAB/2HA ,2HB ,2HC ,2HD ,2HE ,2HF /                         PMT38740
      DATA P/0.15,0.15,0.2,0.25,0.3,0.3/                                PMT38750
      DATA AZ/.24,.24,.20,.14,.08,.08/                                  PMT38760
      DATA BZ/.001,.001,0.,.0003,.0015,.0015/                           PMT38770
      DATA CZ/.001,.001,0.,0.,0.,0./                                    PMT38780
      DATA SECTAN/0.,.39270,.78540,1.17810,1.57080,1.96350,2.35620,     PMT38790
     1 2.74890,3.14159,3.53429,3.92699,4.31969,4.71239,5.10509,         PMT38800
     2 5.49779,5.89049/                                                 PMT38810
C                                                                       PMT38820
      END                                                               PMT38830
C
C                                                                       PMT38840
C                                                                       PMT38850
C                                                                       PMT38860
      SUBROUTINE XINTEG(XL,XU,EPS,NDIM,FCT,Y,IER,AUX)                   PMT38870
C                     SUBROUTINE XINTEG , PART OF PEM-2 (VERSION 84130). PMT38880
        REAL*8 FCT                                                      PMT38890
C     FOR UNIVAC-1100                                                   PMT38900
      REAL*8 XL,XU,X,Y                                                  PMT38910
C                                                                       PMT38920
      DIMENSION AUX(1)                                                  PMT38930
C                                                                       PMT38940
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C                                                                       PMT38950
C     THIS SUBROUTINE PERFORMS NUMERICAL INTEGRATION OF AN EXTERNALLY   PMT38960
C     DEFINED FUNCTION OVER A FINITE INTERVAL USING THE TRAPEZOIDAL RULEPMT38970
C     WITH ROMBERG EXTRAPOLATION.  THIS ROUTINE IS CALLED IN THE MAIN   PMT38980
C     PROGRAM FOR NUMERICAL INTEGRATIONS W.R.T. X FOR AREA SOURCES.     PMT38990
C                                                                       PMT39000
C     XL = LOWER LIMIT OF INTEGRATION INTERVAL. (INPUT)                 PMT39010
C     XU = UPPER LIMIT OF INTEGRATION INTERVAL. (INPUT)                 PMT39020
C     EPS = UPPER BOUND FOR RELATIVE ERROR BETWEEN SUCCESSIVE           PMT39030
C             APPROXIMATIONS TO THE INTEGRAL. (INPUT)                   PMT39040
C     NDIM = MAXIMUM NO.OF BISECTIONS OF INTERVAL (XL,XU). (INPUT)      PMT39050
C     FCT = EXTERNALLY DEFINED INTEGRAND FUNCTION. (INPUT)              PMT39060
C     Y = BEST POSSIBLE APPROXIMATION OF INTEGRAL. (OUTPUT)             PMT39070
C     IER = ERROR MESSAGE (OUTPUT)                                      PMT39080
C         = 0  NO ERROR                                                 PMT39090
C         = 1  SPECIFIED ACCURACY CANT BE REACHED DUE TO ROUNDING ERRORSPMT39100
C         = 2  IMPOSSIBLE TO CHECK ACCURACY (IF NDIM<5) OR SPECIFIED    PMT39110
C              ACCURACY CAN'T BE REACHED. NDIM SHOULD BE INCREASED.     PMT39120
C     AUX = AUXILIARY STORAGE ARRAY WITH DIMENSION NDIM. (INTERNAL)     PMT39130
C                                                                       PMT39140
C     PEM-2 PROGRAM DEVELOPMENT: DECEMBER 1983                          PMT39150
C     K. SHANKAR RAO                                                    PMT39160
C     NOAA-ATDL, P.O. BOX-E                                             PMT39170
C     OAK RIDGE, TENN 37831                                             PMT39180
C                                                                       PMT39190
C                                                                       PMT39200
C     PREPARATIONS FOR ROMBERG-LOOP                                     PMT39210
      AUX(1)=.5*(FCT(XL)+FCT(XU))                                       PMT39220
      H=XU-XL                                                           PMT39230
      IF(NDIM-1) 8,8,1                                                  PMT39240
    1 IF(H) 2,10,2                                                      PMT39250
C                                                                       PMT39260
C     NDIM IS GREATER THAN 1 AND H IS NOT EQUAL TO 0.                   PMT39270
    2 HH=H                                                              PMT39280
      EPSREL=EPS                                                        PMT39290
      EPSA=1.0E-10                                                      PMT39300
      DELT2=1.E06                                                       PMT39310
      P=1.                                                              PMT39320
      JJ=1                                                              PMT39330
C                                                                       PMT39340
C                                                                       PMT39350
      DO 7 I=2,NDIM                                                     PMT39360
      Y=AUX(1)                                                          PMT39370
      DELT1=DELT2                                                       PMT39380
      HD=HH                                                             PMT39390
      HH=0.5*HH                                                         PMT39400
      P=.5*P                                                            PMT39410
      X=XL+HH                                                           PMT39420
      SUM=0.                                                            PMT39430
C                                                                       PMT39440
C                                                                       PMT39450
      DO 3 J=1,JJ                                                       PMT39460
      SUM=SUM+FCT(X)                                                    PMT39470
    3 X=X+HD                                                            PMT39480
      AUX(I)=.5*AUX(I-1)+P*SUM                                          PMT39490
C                                                                       PMT39500
C     A NEW APPROXIMATION OF INTEGRAL VALUE IS COMPUTED BY MEANS OF     PMT39510
C     TRAPEZOIDAL RULE.                                                 PMT39520
C                                                                       PMT39530
C     START OF ROMBERG EXTRAPOLATION METHOD.                            PMT39540
      Q=1.                                                              PMT39550
      IM1=I-1                                                           PMT39560
      DO 4 J=1,IM1                                                      PMT39570
      II=I-J                                                            PMT39580
      Q=Q+Q                                                             PMT39590
      Q=Q+Q                                                             PMT39600
    4 AUX(II)=AUX(II+1)+(AUX(II+1)-AUX(II))/(Q-1.)                      PMT39610
C     END OF ROMBERG-STEP                                               PMT39620
C     FINAL VALUE OF AUX(II)=AUX(1) WHICH CONTAINS VALUE OF             PMT39630
C     INTEGRAL FOR THIS APPROXIMATION.                                  PMT39640
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C                                                                       PMT39650
C     TESTS FOR CONVERGENCE                                             PMT39660
      IF(Y.GT.EPSA) DELT2=ABS(Y-AUX(1))/Y                               PMT39670
      IF(Y.LE.EPSA) DELT2=0.                                            PMT39680
      IF(I-2) 7,5,5                                                     PMT39690
    5 IF(DELT2-EPSREL) 10,10,6                                          PMT39700
    6 IF(DELT2-DELT1) 7,11,11                                           PMT39710
    7 JJ=JJ+JJ                                                          PMT39720
C     END LOOP ON APPROXIMATIONS                                        PMT39730
C                                                                       PMT39740
C                                                                       PMT39750
    8 IER=2                                                             PMT39760
    9 Y=H*AUX(1)                                                        PMT39770
      RETURN                                                            PMT39780
C                                                                       PMT39790
C                                                                       PMT39800
   10 IER=0                                                             PMT39810
      GO TO 9                                                           PMT39820
C                                                                       PMT39830
C                                                                       PMT39840
   11 IER=1                                                             PMT39850
      Y=H*Y                                                             PMT39860
      RETURN                                                            PMT39870
      END                                                               PMT39880
C
C                                                                       PMT39890
C                                                                       PMT39900
C                                                                       PMT39910
C                                                                       PMT39920
      SUBROUTINE D01AJF(F, A, B, EPSABS, EPSREL, RESULT, ABSERR,WORK,   PMT39930
     * LWORK, IWORK, LIWORK, IFAIL)                                     PMT39940
C                    SUBROUTINE D01AJF , PART OF PEM-2 (VERSION 84130). PMT39950
C                                                                       PMT39960
C     MARK 8 RELEASE. NAG COPYRIGHT 1980                                PMT39970
C                                                                       PMT39980
C     D01AJF IS A GENERAL PURPOSE INTEGRATOR WHICH CALCULATES           PMT39990
C     AN APPROXIMATION TO THE INTEGRAL OF A FUNCTION OVER A FINITE      PMT40000
C     INTERVAL (A,B).  THIS ROUTINE CAN BE USED WHEN THE INTEGRAND      PMT40010
C     HAS SINGULARITIES, ESPECIALLY WHEN THESE ARE OF ALGEBRAIC OR      PMT40020
C     LOGARITHMIC TYPE.  D01AJF IS AN ADAPTIVE ROUTINE, USING THE       PMT40030
C     GAUSS 10-POINT AND KRONROD 21-POINT RULES.  THE ALGORITHM         PMT40040
C     INCORPORATES A GLOBAL ACCEPTANCE CRITERION TOGETHER WITH          PMT40050
C     EPS-ALGORITHM TO PERFORM EXTRAPOLATION.  THE LOCAL ERROR IS       PMT40060
C     ESTIMATED.                                                        PMT40070
C                                                                       PMT40080
C     THE GENERAL PURPOSE INTEGRATOR D01AJF INCLUDES THE FOLLOWING:     PMT40090
C     SUBROUTINES (1) D01AJF, (2) D01AJV, (3) D01AJX, (4) D01AJY,       PMT40100
C     (5) D01AJZ, INTEGER FUNCTION P01AAF, DOUBLE PRECISION FUNCTIONS   PMT40110
C     (1) X02AAF, (2) X02ABF, (3) X02ACF, AND SUBROUTINE X04AAF.        PMT40120
C     THE PROGRAM LISTINGS FOR THESE SUBROUTINES AND FUNCTIONS, COPIED  PMT40130
C     HERE FROM ORNL - NAG LIBRARY, FOLLOW.  THESE ARE DEVELOPED BY     PMT40140
C          NUMERICAL ALGORITHMS GROUP (NAG)                             PMT40150
C          1131 WARREN AVENUE                                           PMT40160
C          DOWNERS GROVE, ILLINOIS 60515                                PMT40170
C     WHICH HOLDS THE COPYRIGHT (NAG FORTRAN MINI MANUAL, MARK8, 1980). PMT40180
C     THESE PROGRAM LISTINGS ARE INCLUDED HERE WITH THEIR KIND          PMT40190
C     PERMISSION.  THEY ARE RELEASED BY                                 PMT40200
C          COMPUTER SCIENCES DEPARTMENT                                 PMT40210
C          OAK RIDGE NATIONAL LABORATORY (ORNL)                         PMT40220
C          OAK RIDGE, TENNESSEE 37831                                   PMT40230
C     EXCLUSIVELY FOR USE IN THE PEM.  THESE LIBRARY SUBROUTINES AND    PMT40240
C     PROGRAMS SHOULD NOT BE USED FOR ANY OTHER PURPOSE WITHOUT PRIOR   PMT40250
C     APPROVAL FROM NAG AND ORNL.                                       PMT40260
C                                                                       PMT40270
C                                                                       PMT40280
C     D01AJF ITSELF IS ESSENTIALLY A DUMMY ROUTINE WHOSE FUNCTION IS TO PMT40290
C     PARTITION THE WORK ARRAYS WORK AND IWORK FOR USE BY D01AJV.       PMT40300
C     WORK IS PARTITIONED INTO 4 ARRAYS EACH OF SIZE LWORK/4.           PMT40310
C     IWORK IS A SINGLE ARRAY IN D01AJV.                                PMT40320
C                                                                       PMT40330
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C     .. SCALAR ARGUMENTS ..                                            PMT40340
      DOUBLE PRECISION A, ABSERR, B, EPSABS, EPSREL, RESULT             PMT40350
      INTEGER IFAIL, LIWORK, LWORK                                      PMT40360
C     .. ARRAY ARGUMENTS ..                                             PMT40370
      DOUBLE PRECISION WORK(LWORK)                                      PMT40380
      INTEGER IWORK(LIWORK)                                             PMT40390
C     .. FUNCTION ARGUMENTS ..                                          PMT40400
      DOUBLE PRECISION F                                                PMT40410
C     ..                                                                PMT40420
C     .. LOCAL SCALARS ..                                               PMT40430
C$P 1                                                                   PMT40440
      DOUBLE PRECISION SRNAME                                           PMT40450
      INTEGER IBL, IEL, IER, IRL, LIMIT                                 PMT40460
C     .. FUNCTION REFERENCES ..                                         PMT40470
      INTEGER P01AAF                                                    PMT40480
C     .. SUBROUTINE REFERENCES ..                                       PMT40490
C     D01AJV                                                            PMT40500
C     ..                                                                PMT40510
      EXTERNAL F                                                        PMT40520
      DATA SRNAME /8H D01AJF /                                          PMT40530
C     CHECK THAT MINIMUM WORKSPACE REQUIREMENTS ARE MET                 PMT40540
      IF (LWORK.LT.4) GO TO 20                                          PMT40550
      IF (LIWORK.LT.LWORK/8+2) GO TO 20                                 PMT40560
C     LIMIT = UPPER BOUND ON NUMBER OF SUBINTERVALS                     PMT40570
      LIMIT = LWORK/4                                                   PMT40580
C     SET UP BASE ADDRESSES FOR WORK ARRAYS                             PMT40590
      IBL = LIMIT + 1                                                   PMT40600
      IEL = LIMIT + IBL                                                 PMT40610
      IRL = LIMIT + IEL                                                 PMT40620
C     PERFORM INTEGRATION                                               PMT40630
      CALL D01AJV(F, A, B, DABS(EPSABS), DABS(EPSREL), WORK(1),WORK(IBL)PMT40640
     *, WORK(IEL), WORK(IRL), LIMIT, IWORK, LIWORK,RESULT, ABSERR, IER) PMT40650
      IF (IER.NE.0) GO TO 40                                            PMT40660
      IFAIL = 0                                                         PMT40670
      GO TO 60                                                          PMT40680
C     ERROR 6 = INSUFFICIENT WORKSPACE                                  PMT40690
   20 IER = 6                                                           PMT40700
   40 IFAIL = P01AAF(IFAIL,IER,SRNAME)                                  PMT40710
   60 RETURN                                                            PMT40720
      END                                                               PMT40730
C
C                                                                       PMT40740
C                                                                       PMT40750
      SUBROUTINE D01AJV(F, A, B, EPSABS, EPSREL, ALIST, BLIST,ELIST,    PMT40760
     * RLIST, LIMIT, IORD, LIORD, RESULT, ABSERR, IER)                  PMT40770
C                    SUBROUTINE D01AJV , PART OF PEM-2 (VERSION 84130). PMT40780
C                                                                       PMT40790
C     MARK 8 RELEASE. NAG COPYRIGHT 1979                                PMT40800
C     BASED ON QUADPACK ROUTINE DQAGS (FORMERLY QAGS)                   PMT40810
C     ******************************************************            PMT40820
C                                                                       PMT40830
C        PURPOSE                                                        PMT40840
C           THE ROUTINE CALCULATES AN APPROXIMATION                     PMT40850
C           /RESULT/ TO A GIVEN DEFINITE INTEGRAL   I =                 PMT40860
C           INTEGRAL OF /F/ OVER (A,B), HOPEFULLY                       PMT40870
C           SATISFYING FOLLOWING CLAIM FOR ACCURACY .                   PMT40880
C           ABS(I-RESULT) .LE. MAX(EPSABS,EPSREL*ABS(I)).               PMT40890
C                                                                       PMT40900
C          CALLING SEQUENCE                                             PMT40910
C           CALL D01AJV (F,A,B,EPSABS,EPSREL,ALIST,BLIST,ELIST,         PMT40920
C                        RLIST,LIMIT,IORD,LIORD,RESULT,ABSERR,IER)      PMT40930
C                                                                       PMT40940
C        PARAMETERS                                                     PMT40950
C            F      - FUNCTION SUBPROGRAM DEFINING THE INTEGRAND        PMT40960
C                     FUNCTION F(X). THE ACTUAL NAME FOR F              PMT40970
C                     NEEDS TO BE DECLARED E X T E R N A L              PMT40980
C                     IN THE DRIVER PROGRAM                             PMT40990
C                                                                       PMT41000
C            A      - LOWER LIMIT OF INTEGRATION                        PMT41010
C                                                                       PMT41020
```

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C           B       - UPPER LIMIT OF INTEGRATION                          PMT41030
C                                                                         PMT41040
C           EPSABS - ABSOLUTE ACCURACY REQUESTED                          PMT41050
C                                                                         PMT41060
C           EPSREL - RELATIVE ACCURACY REQUESTED                          PMT41070
C                                                                         PMT41080
C           ALIST,BLIST,ELIST,RLIST                                       PMT41090
C                  - WORK ARRAYS (FUNCTIONS DESCRIBED BELOW)              PMT41100
C                                                                         PMT41110
C           LIMIT  - UPPER BOUND FOR NUMBER OF SUBINTERVALS               PMT41120
C                                                                         PMT41130
C           IORD   - WORK ARRAY                                           PMT41140
C                                                                         PMT41150
C           LIORD  - LENGTH OF IORD (AT LEAST LIMIT/2 + 2)                PMT41160
C                                                                         PMT41170
C           RESULT - APPROXIMATION TO THE INTEGRAL                        PMT41180
C                                                                         PMT41190
C           ABSERR - ESTIMATE OF THE MODULUS OF THE ABSOLUTE ERROR,       PMT41200
C                    WHICH SHOULD EQUAL OR EXCEED ABS(I-RESULT)           PMT41210
C                                                                         PMT41220
C           IER    - IER   = 0 NORMAL AND RELIABLE                        PMT41230
C                            TERMINATION OF THE ROUTINE.                  PMT41240
C                            IT IS ASSUMED THAT THE                       PMT41250
C                            REQUESTED  ACCURACY HAS BEEN                 PMT41260
C                            ACHIEVED.                                    PMT41270
C                  - IER   .NE. 0 ABNORMAL TERMINATION OF                 PMT41280
C                            THE ROUTINE. THE ESTIMATES                   PMT41290
C                            FOR INTEGRAL AND ERROR ARE                   PMT41300
C                            LESS RELIABLE. IT IS ASSUMED                 PMT41310
C                            THAT THE  REQUESTED ACCURACY                 PMT41320
C                            HAS NOT BEEN ACHIEVED.                       PMT41330
C                        = 1 MAXIMUM NUMBER OF SUBDIVISIONS ALLOWED       PMT41340
C                            HAS BEEN ACHIEVED. THE USER CAN              PMT41350
C                            ALLOW MORE SUB DIVISIONS BY                  PMT41360
C                            INCREASING THE DIMENSIONS OF THE             PMT41370
C                            WORK ARRAYS WORK AND IWORK.                  PMT41380
C                            HOWEVER, THIS MAY                            PMT41390
C                            YIELD NO  IMPROVEMENT, AND IT                PMT41400
C                            IS RATHER ADVISED TO HAVE A                  PMT41410
C                            CLOSE LOOK AT THE INTEGRAND,                 PMT41420
C                            IN ORDER TO DETERMINE THE                    PMT41430
C                            INTEGRATION  DIFFICULTIES. IF                PMT41440
C                            THE POSITION OF A LOCAL                      PMT41450
C                            DIFFICULTY CAN BE DETERMINED                 PMT41460
C                            (I.E.  SINGULARITY,                          PMT41470
C                            DISCONTINUITY WITHIN THE                     PMT41480
C                            INTERVAL) ONE WILL PROBABLY                  PMT41490
C                            GAIN FROM  SPLITTING UP THE                  PMT41500
C                            INTERVAL AT THIS POINT AND                   PMT41510
C                            CALLING THE INTEGRATOR ON THE                PMT41520
C                            SUB-RANGES. IF POSSIBLE, AN                  PMT41530
C                            APPROPRIATE SPECIAL-PURPOSE                  PMT41540
C                            INTEGRATOR SHOULD BE USED                    PMT41550
C                            WHICH IS DESIGNED FOR                        PMT41560
C                            HANDLING THE TYPE  OF                        PMT41570
C                            DIFFICULTY INVOLVED.                         PMT41580
C                        = 2 THE OCCURRENCE OF ROUNDOFF                   PMT41590
C                            ERROR IS DETECTED WHICH                      PMT41600
C                            PREVENTS THE REQUESTED                       PMT41610
C                            TOLERANCE  FROM BEING                        PMT41620
C                            ACHIEVED. THE ERROR MAY BE                   PMT41630
C                            UNDER-ESTIMATED.                             PMT41640
C                        = 3 EXTREMELY BAD INTEGRAND BEHAVIOUR            PMT41650
C                            OCCURS AT SOME INTERIOR POINTS OF THE        PMT41660
C                            INTEGRATION INTERVAL.                        PMT41670
C                        = 4 IT IS PRESUMED THAT THE REQUESTED            PMT41680
C                            TOLERANCE CANNOT BE ACHIEVED,                PMT41690
C                            AND THAT THE RETURNED RESULT                 PMT41700
C                            IS THE BEST WHICH CAN BE                     PMT41710
C                            OBTAINED.                                    PMT41720
```

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C                          = 5 THE INTEGRAL IS PROBABLY DIVERGENT, OR
C                              SLOWLY CONVERGENT. IT MUST BE NOTED
C                              THAT DIVERGENCY CAN OCCUR
C                              WITH ANY OTHER VALUE OF IER.
C
C     ******************************************************
C     .. SCALAR ARGUMENTS ..
      DOUBLE PRECISION A, ABSERR, B, EPSABS, EPSREL, RESULT
      INTEGER IER, LIMIT, LIORD
C     .. ARRAY ARGUMENTS ..
      DOUBLE PRECISION ALIST(LIMIT), BLIST(LIMIT), ELIST(LIMIT),
     * RLIST(LIMIT)
      INTEGER IORD(LIORD)
C     .. FUNCTION ARGUMENTS ..
      DOUBLE PRECISION F
C     ..
C     .. SCALARS IN COMMON ..
      INTEGER JUPBND
C     ..
C     .. LOCAL SCALARS ..
      DOUBLE PRECISION A1, A2, ABSEPS, AREA12, AREA1, AREA2, AREA, B1,
     * B2,CORREC, DEFAB1, DEFAB2, DEFABS, DRES, EPMACH, ERLARG,ERLAST,
     * ERRBND, ERRMAX, ERRO12, ERROR1, ERROR2, ERRSUM,ERTEST, OFLOW,
     * RESABS, RESEPS, SMALL, UFLOW
      INTEGER ID, IERRO, IROFF1, IROFF2, IROFF3, K, KSGN, KTMIN,LAST1,
     * LAST, MAXERR, NRES, NRMAX, NUMRL2
      LOGICAL EXTRAP, NOEXT
C     .. LOCAL ARRAYS ..
      DOUBLE PRECISION RES3LA(3), RLIST2(52)
C     .. FUNCTION REFERENCES ..
      DOUBLE PRECISION X02AAF, X02ABF, X02ACF
C     .. SUBROUTINE REFERENCES ..
C     D01AJX, D01AJY, D01AJZ
C     ..
      EXTERNAL F
      COMMON /AD01AJ/ JUPBND
C
C            THE DIMENSION OF /RLIST2/ IS DETERMINED BY
C            DATA /LIMEXP/ IN SUBROUTINE D01AJY (/RLIST2/
C            SHOULD BE OF DIMENSION (LIMEXP+2) AT LEAST).
C
      EPMACH = X02AAF()
      UFLOW = X02ABF()
      OFLOW = X02ACF()
C
C            LIST OF MAJOR VARIABLES
C            -----------------------
C
C           ALIST     - LIST OF LEFT END-POINTS OF ALL SUBINTERVALS
C                       CONSIDERED UP TO NOW
C
C           BLIST     - LIST OF RIGHT END-POINTS OF ALL SUBINTERVALS
C                       CONSIDERED UP TO NOW
C
C           RLIST(I)  - APPROXIMATION TO THE INTEGRAL OVER
C                       (ALIST(I),BLIST(I))
C
C           RLIST2    - ARRAY OF DIMENSION AT LEAST LIMEXP+2
C                       CONTAINING THE PART OF THE EPSILON TABLE
C                       WHICH IS STILL NEEDED FOR FURTHER
C                       COMPUTATIONS
C
C           ELIST(I)  - ERROR ESTIMATE APPLYING TO RLIST(I)
C
C           MAXERR    - POINTER TO THE INTERVAL WITH LARGEST ERROR
C                       ESTIMATE
C
C           ERRMAX    - ELIST(MAXERR)
C
C           ERLAST    - ERROR ON THE INTERVAL CURRENTLY SUBDIVIDED
```

```
C                       (BEFORE THAT SUBDIVISION HAS TAKEN PLACE)
C
C           AREA      - SUM OF THE INTEGRALS OVER THE SUBINTERVALS
C
C           ERRSUM    - SUM OF THE ERRORS OVER THE SUBINTERVALS
C
C           ERRBND    - REQUESTED ACCURACY MAX(EPSABS,EPSREL*
C                       ABS(RESULT))
C
C           *****1    - VARIABLE FOR THE LEFT INTERVAL
C
C           *****2    - VARIABLE FOR THE RIGHT INTERVAL
C
C           LAST      - INDEX FOR SUBDIVISION
C
C           NRES      - NUMBER OF CALLS TO THE EXTRAPOLATION ROUTINE
C
C           NUMRL2    - NUMBER OF ELEMENTS CURRENTLY  IN
C                       RLIST2. IF AN APPROPRIATE
C                       APPROXIMATION TO THE COMPOUNDED
C                       INTEGRAL HAS BEEN OBTAINED IT IS
C                       PUT IN  RLIST2(NUMRL2) AFTER NUMRL2
C                       HAS BEEN INCREASED BY ONE.
C
C           SMALL     - LENGTH OF THE SMALLEST INTERVAL CONSIDERED
C                       UP TO NOW, MULTIPLIED BY 1.5
C
C           ERLARG    - SUM OF THE ERRORS OVER THE INTERVALS LARGER
C                       THAN THE SMALLEST INTERVAL
C                       CONSIDERED UP TO NOW
C           EXTRAP    - LOGICAL VARIABLE DENOTING THAT THE
C                       ROUTINE IS ATTEMPTING TO PERFORM
C                       EXTRAPOLATION.  I.E. BEFORE
C                       SUBDIVIDING THE SMALLEST INTERVAL
C                       WE TRY TO DECREASE THE VALUE OF
C                       ERLARG
C           NOEXT     - LOGICAL VARIABLE DENOTING THAT EXTRAPOLATION
C                       IS NO LONGER ALLOWED(/TRUE/ VALUE)
C
C           FIRST APPROXIMATION TO THE INTEGRAL
C           -----------------------------------
C
      LAST1 = 1
      IER = 0
      IERRO = 0
      CALL D01AJZ(F, A, B, RESULT, ABSERR, DEFABS, RESABS)
C
C           TEST ON ACCURACY
C
      DRES = DABS(RESULT)
      ERRBND = DMAX1(EPSABS,EPSREL*DRES)
      IF (ABSERR.LE.1.0D+02*EPMACH*DEFABS .AND. ABSERR.GT.ERRBND)IER = 2
      IF (LIMIT.LT.2 .AND. ABSERR.GT.ERRBND) IER = 1
      IF (IER.NE.0 .OR. ABSERR.LE.ERRBND) GO TO 320
C
C           INITIALIZATION
C           --------------
C
      ALIST(1) = A
      BLIST(1) = B
      RLIST(1) = RESULT
      RLIST2(1) = RESULT
      ERRMAX = ABSERR
      MAXERR = 1
      AREA = RESULT
      ERRSUM = ABSERR
      ABSERR = OFLOW
      NRMAX = 1
      NRES = 0
      NUMRL2 = 2
```

```
      KTMIN = 0                                                         PMT43130
      EXTRAP = .FALSE.                                                  PMT43140
      NOEXT = .FALSE.                                                   PMT43150
      IROFF1 = 0                                                        PMT43160
      IROFF2 = 0                                                        PMT43170
      IROFF3 = 0                                                        PMT43180
      KSGN = -1                                                         PMT43190
      IF (DRES.GE.(0.1D+01-0.5D+02*EPMACH)*DEFABS) KSGN = 1             PMT43200
C                                                                       PMT43210
C           MAIN DO-LOOP                                                PMT43220
C           ------------                                                PMT43230
C                                                                       PMT43240
      IF (LIMIT.LT.2) GO TO 220                                         PMT43250
      DO 200 LAST=2,LIMIT                                               PMT43260
C                                                                       PMT43270
C           BISECT THE SUBINTERVAL WITH THE NRMAX-TH LARGEST            PMT43280
C           ERROR ESTIMATE                                              PMT43290
C                                                                       PMT43300
         LAST1 = LAST                                                   PMT43310
         A1 = ALIST(MAXERR)                                             PMT43320
         B1 = 0.5D+00*(ALIST(MAXERR)+BLIST(MAXERR))                     PMT43330
         A2 = B1                                                        PMT43340
         B2 = BLIST(MAXERR)                                             PMT43350
         ERLAST = ERRMAX                                                PMT43360
         CALL D01AJZ(F, A1, B1, AREA1, ERROR1, RESABS, DEFAB1)          PMT43370
         CALL D01AJZ(F, A2, B2, AREA2, ERROR2, RESABS, DEFAB2)          PMT43380
C                                                                       PMT43390
C           IMPROVE PREVIOUS APPROXIMATION OF INTEGRAL                  PMT43400
C           AND ERROR AND TEST FOR ACCURACY                             PMT43410
C                                                                       PMT43420
         AREA12 = AREA1 + AREA2                                         PMT43430
         ERRO12 = ERROR1 + ERROR2                                       PMT43440
         ERRSUM = ERRSUM + ERRO12 - ERRMAX                              PMT43450
         AREA = AREA + AREA12 - RLIST(MAXERR)                           PMT43460
         IF (DEFAB1.EQ.ERROR1 .OR. DEFAB2.EQ.ERROR2) GO TO 40           PMT43470
         IF (DABS(RLIST(MAXERR)-AREA12).GT.0.1D-04*DABS(AREA12) .OR.    PMT43480
     *   ERRO12.LT.0.99D+00*ERRMAX) GO TO 20                            PMT43490
         IF (EXTRAP) IROFF2 = IROFF2 + 1                                PMT43500
         IF (.NOT.EXTRAP) IROFF1 = IROFF1 + 1                           PMT43510
   20    IF (LAST.GT.10 .AND. ERRO12.GT.ERRMAX) IROFF3 = IROFF3 + 1     PMT43520
   40    RLIST(MAXERR) = AREA1                                          PMT43530
         RLIST(LAST) = AREA2                                            PMT43540
         ERRBND = DMAX1(EPSABS,EPSREL*DABS(AREA))                       PMT43550
         IF (ERRSUM.LE.ERRBND) GO TO 280                                PMT43560
C                                                                       PMT43570
C           TEST FOR ROUNDOFF ERROR AND EVENTUALLY                      PMT43580
C           SET ERROR FLAG                                              PMT43590
C                                                                       PMT43600
         IF (IROFF1+IROFF2.GE.10 .OR. IROFF3.GE.20) IER = 2             PMT43610
         IF (IROFF2.GE.5) IERRO = 3                                     PMT43620
C                                                                       PMT43630
C           SET ERROR FLAG IN THE CASE THAT THE NUMBER OF INTERVAL      PMT43640
C            BISECTIONS EXCEEDS /LIMIT/                                 PMT43650
C                                                                       PMT43660
         IF (LAST.EQ.LIMIT) IER = 1                                     PMT43670
C                                                                       PMT43680
C           SET ERROR FLAG IN THE CASE OF BAD INTEGRAND BEHAVIOUR       PMT43690
C           AT INTERIOR POINTS OF INTEGRATION RANGE                     PMT43700
C                                                                       PMT43710
         IF (DMAX1(DABS(A1),DABS(B2)).LE.(0.1D+01+0.1D+03*EPMACH)*      PMT43720
     *   (DABS(A2)+0.1D+04*UFLOW)) IER = 4                              PMT43730
         IF (IER.NE.0) GO TO 220                                        PMT43740
C                                                                       PMT43750
C           APPEND THE NEWLY-CREATED INTERVALS TO THE LIST              PMT43760
C                                                                       PMT43770
         IF (ERROR2.GT.ERROR1) GO TO 60                                 PMT43780
         ALIST(LAST) = A2                                               PMT43790
         BLIST(MAXERR) = B1                                             PMT43800
         BLIST(LAST) = B2                                               PMT43810
         ELIST(MAXERR) = ERROR1                                         PMT43820
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      ELIST(LAST) = ERROR2                                              PMT43830
      GO TO 80                                                          PMT43840
   60 ALIST(MAXERR) = A2                                                PMT43850
      ALIST(LAST) = A1                                                  PMT43860
      BLIST(LAST) = B1                                                  PMT43870
      RLIST(MAXERR) = AREA2                                             PMT43880
      RLIST(LAST) = AREA1                                               PMT43890
      ELIST(MAXERR) = ERROR2                                            PMT43900
      ELIST(LAST) = ERROR1                                              PMT43910
C                                                                       PMT43920
C        CALL SUBROUTINE D01AJX TO MAINTAIN THE                         PMT43930
C        DESCENDING ORDERING IN THE LIST OF ERROR                       PMT43940
C        ESTIMATES AND SELECT THE SUBINTERVAL WITH                      PMT43950
C        NRMAX-TH LARGEST ERROR ESTIMATE (TO BE BISECTED                PMT43960
C        NEXT)                                                          PMT43970
C                                                                       PMT43980
   80 CALL D01AJX(LIMIT, LAST, MAXERR, ERRMAX, ELIST, IORD,LIORD,       PMT43990
     *  NRMAX)                                                          PMT44000
      IF (LAST.EQ.2) GO TO 180                                          PMT44010
      IF (NOEXT) GO TO 200                                              PMT44020
      ERLARG = ERLARG - ERLAST                                          PMT44030
      IF (DABS(B1-A1).GT.SMALL) ERLARG = ERLARG + ERRO12                PMT44040
      IF (EXTRAP) GO TO 100                                             PMT44050
C                                                                       PMT44060
C        TEST WHETHER THE INTERVAL TO BE BISECTED NEXT IS THE           PMT44070
C        SMALLEST INTERVAL                                              PMT44080
C                                                                       PMT44090
      IF (DABS(BLIST(MAXERR)-ALIST(MAXERR)).GT.SMALL) GO TO 200         PMT44100
      EXTRAP = .TRUE.                                                   PMT44110
      NRMAX = 2                                                         PMT44120
  100 IF (IERRO.EQ.3 .OR. ERLARG.LE.ERTEST) GO TO 140                   PMT44130
C                                                                       PMT44140
C        THE SMALLEST INTERVAL HAS THE LARGEST ERROR.                   PMT44150
C        BEFORE BISECTING DECREASE THE SUM OF THE ERRORS                PMT44160
C        OVER THE LARGER INTERVALS(ERLARG) AND PERFORM                  PMT44170
C        EXTRAPOLATION                                                  PMT44180
C                                                                       PMT44190
      ID = NRMAX                                                        PMT44200
      DO 120 K=ID,JUPBND                                                PMT44210
         MAXERR = IORD(NRMAX)                                           PMT44220
         ERRMAX = ELIST(MAXERR)                                         PMT44230
         IF (DABS(BLIST(MAXERR)-ALIST(MAXERR)).GT.SMALL) GO TO 200      PMT44240
         NRMAX = NRMAX + 1                                              PMT44250
  120 CONTINUE                                                          PMT44260
C                                                                       PMT44270
C        PERFORM EXTRAPOLATION                                          PMT44280
C                                                                       PMT44290
  140 NUMRL2 = NUMRL2 + 1                                               PMT44300
      RLIST2(NUMRL2) = AREA                                             PMT44310
      CALL D01AJY(NUMRL2, RLIST2, RESEPS, ABSEPS, RES3LA, NRES)         PMT44320
      KTMIN = KTMIN + 1                                                 PMT44330
      IF (KTMIN.GT.5 .AND. ABSERR.LT.0.1D-02*ERRSUM) IER = 5            PMT44340
      IF (ABSEPS.GE.ABSERR) GO TO 160                                   PMT44350
      KTMIN = 0                                                         PMT44360
      ABSERR = ABSEPS                                                   PMT44370
      RESULT = RESEPS                                                   PMT44380
      CORREC = ERLARG                                                   PMT44390
      ERTEST = DMAX1(EPSABS,EPSREL*DABS(RESEPS))                        PMT44400
      IF (ABSERR.LE.ERTEST) GO TO 220                                   PMT44410
C                                                                       PMT44420
C        PREPARE  BISECTION OF THE SMALLEST INTERVAL                    PMT44430
C                                                                       PMT44440
  160 IF (NUMRL2.EQ.1) NOEXT = .TRUE.                                   PMT44450
      IF (IER.EQ.5) GO TO 220                                           PMT44460
      MAXERR = IORD(1)                                                  PMT44470
      ERRMAX = ELIST(MAXERR)                                            PMT44480
      NRMAX = 1                                                         PMT44490
      EXTRAP = .FALSE.                                                  PMT44500
      SMALL = SMALL*0.5D+00                                             PMT44510
      ERLARG = ERRSUM                                                   PMT44520
```

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      GO TO 200                                                         PMT44530
  180 SMALL = DABS(B-A)*0.375D+00                                       PMT44540
      ERLARG = ERRSUM                                                   PMT44550
      ERTEST = ERRBND                                                   PMT44560
      RLIST2(2) = AREA                                                  PMT44570
  200 CONTINUE                                                          PMT44580
C                                                                       PMT44590
C           SET  FINAL RESULT AND ERROR ESTIMATE                        PMT44600
C           ------------------------------------                        PMT44610
C                                                                       PMT44620
  220 IF (ABSERR.EQ.OFLOW) GO TO 280                                    PMT44630
      IF (IER+IERRO.EQ.0) GO TO 260                                     PMT44640
      IF (IERRO.EQ.3) ABSERR = ABSERR + CORREC                          PMT44650
      IF (IER.EQ.0) IER = 3                                             PMT44660
      IF (RESULT.NE.0.D+00.AND .AREA. NE.0.D+00) GO TO 240              PMT44670
      IF (ABSERR.GT.ERRSUM) GO TO 280                                   PMT44680
      IF (AREA.EQ.0.D+00) GO TO 320                                     PMT44690
      GO TO 260                                                         PMT44700
  240 IF (ABSERR/DABS(RESULT).GT.ERRSUM/DABS(AREA)) GO TO 280           PMT44710
C                                                                       PMT44720
C           TEST ON DIVERGENCY                                          PMT44730
C                                                                       PMT44740
  260 IF (KSGN.EQ.-1 .AND. DMAX1(DABS(RESULT),DABS(AREA)).LE.DEFABS*     PMT44750
     *0.1D-01) GO TO 320                                                PMT44760
      IF (0.1D-01.GT.(RESULT/AREA) .OR. (RESULT/AREA).GT.0.1D+03.OR.    PMT44770
     * ERRSUM.GT.DABS(AREA)) IER = 6                                    PMT44780
      GO TO 320                                                         PMT44790
C                                                                       PMT44800
C           COMPUTE GLOBAL INTEGRAL SUM                                 PMT44810
C                                                                       PMT44820
  280 RESULT = 0.D+00                                                   PMT44830
      DO 300 K=1,LAST                                                   PMT44840
         RESULT = RESULT + RLIST(K)                                     PMT44850
  300 CONTINUE                                                          PMT44860
      ABSERR = ERRSUM                                                   PMT44870
  320 IF (IER.GT.2) IER = IER - 1                                       PMT44880
      IORD(1) = 4*LAST1                                                 PMT44890
      RETURN                                                            PMT44900
      END                                                               PMT44910
C
C                                                                       PMT44920
C                                                                       PMT44930
      SUBROUTINE D01AJX(LIMIT, LAST, MAXERR, ERMAX, ELIST, IORD,LIORD,  PMT44940
     * NRMAX)                                                           PMT44950
C                     SUBROUTINE D01AJX , PART OF PEM-2 (VERSION 84130). PMT44960
C                                                                       PMT44970
C     MARK 8 RELEASE. NAG COPYRIGHT 1979                                PMT44980
C     BASED ON QUADPACK ROUTINE ORDER                                   PMT44990
C     ***************************************************               PMT45000
C                                                                       PMT45010
C           PURPOSE                                                     PMT45020
C              THIS ROUTINE MAINTAINS THE DESCENDING ORDERING           PMT45030
C              IN THE LIST OF THE LOCAL ERROR ESTIMATES                 PMT45040
C              RESULTING FROM THE INTERVAL SUBDIVISION                  PMT45050
C              PROCESS. AT EACH CALL TWO ERROR ESTIMATES                PMT45060
C              ARE INSERTED USING THE SEQUENTIAL SEARCH                 PMT45070
C              METHOD . TOP-DOWN FOR THE LARGEST ERROR                  PMT45080
C              ESTIMATE,  BOTTOM-UP FOR THE SMALLEST ERROR              PMT45090
C              ESTIMATE.                                                PMT45100
C                                                                       PMT45110
C           CALLING SEQUENCE                                            PMT45120
C              CALL D01AJX                                              PMT45130
C              (LIMIT,LAST,MAXERR,ERMAX,ELIST,IORD,LIORD,NRMAX)         PMT45140
C                                                                       PMT45150
C             PARAMETERS (MEANING AT OUTPUT)                            PMT45160
C              LIMIT  - MAXIMUM NUMBER OF ERROR ESTIMATES THE LIST      PMT45170
C                       CAN CONTAIN                                     PMT45180
C                                                                       PMT45190
C              LAST   - NUMBER OF ERROR ESTIMATES CURRENTLY             PMT45200
C                       IN THE LIST. ELIST(LAST) CONTAINS               PMT45210
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C                       THE SMALLEST ERROR ESTIMATE.                      PMT45220
C                                                                         PMT45230
C               MAXERR - MAXERR POINTS TO THE NRMAX-TH LARGEST ERROR      PMT45240
C                        ESTIMATE CURRENTLY IN THE LIST.                  PMT45250
C                                                                         PMT45260
C               ERMAX  - NRMAX-TH LARGEST ERROR ESTIMATE                  PMT45270
C                        ERMAX = ELIST(MAXERR)                            PMT45280
C                                                                         PMT45290
C               ELIST  - ARRAY OF DIMENSION LAST CONTAINING               PMT45300
C                        THE ERROR ESTIMATES                              PMT45310
C                                                                         PMT45320
C               IORD   - ARRAY CONTAINING POINTERS TO ELIST SO            PMT45330
C                        THAT IORD(1) POINTS TO THE LARGEST               PMT45340
C                        ERROR ESTIMATE,...,IORD(LAST) TO THE             PMT45350
C                        SMALLEST ERROR ESTIMATE                          PMT45360
C                                                                         PMT45370
C               LIORD  - DIMENSION OF IORD                                PMT45380
C                                                                         PMT45390
C               NRMAX  - MAXERR = IORD(NRMAX)                             PMT45400
C                                                                         PMT45410
C     ***************************************************                 PMT45420
C                                                                         PMT45430
C     .. SCALAR ARGUMENTS ..                                              PMT45440
      DOUBLE PRECISION ERMAX                                              PMT45450
      INTEGER LAST, LIMIT, LIORD, MAXERR, NRMAX                           PMT45460
C     .. ARRAY ARGUMENTS ..                                               PMT45470
      DOUBLE PRECISION ELIST(LAST)                                        PMT45480
      INTEGER IORD(LIORD)                                                 PMT45490
C     ..                                                                  PMT45500
C     .. SCALARS IN COMMON ..                                             PMT45510
      INTEGER JUPBND                                                      PMT45520
C     ..                                                                  PMT45530
C     .. LOCAL SCALARS ..                                                 PMT45540
      DOUBLE PRECISION ERRMAX, ERRMIN                                     PMT45550
      INTEGER I, IBEG, IDO, ISUCC, J, JBND, K                             PMT45560
C     ..                                                                  PMT45570
      COMMON /AD01AJ/ JUPBND                                              PMT45580
C                                                                         PMT45590
C             CHECK WHETHER THE LIST CONTAINS MORE THAN                   PMT45600
C             TWO ERROR ESTIMATES                                         PMT45610
C                                                                         PMT45620
      IF (LAST.GT.2) GO TO 20                                             PMT45630
      IORD(1) = 1                                                         PMT45640
      IORD(2) = 2                                                         PMT45650
      GO TO 180                                                           PMT45660
C                                                                         PMT45670
C           THIS PART OF THE ROUTINE IS ONLY EXECUTED                     PMT45680
C           IF, DUE TO A DIFFICULT INTEGRAND, SUBDIVISION                 PMT45690
C           INCREASED THE ERROR ESTIMATE. IN THE NORMAL CASE              PMT45700
C           THE INSERT PROCEDURE SHOULD START AFTER THE                   PMT45710
C           NRMAX-TH LARGEST ERROR ESTIMATE.                              PMT45720
C                                                                         PMT45730
   20 ERRMAX = ELIST(MAXERR)                                              PMT45740
      IF (NRMAX.EQ.1) GO TO 60                                            PMT45750
      IDO = NRMAX - 1                                                     PMT45760
      DO 40 I=1,IDO                                                       PMT45770
         ISUCC = IORD(NRMAX-1)                                            PMT45780
         IF (ERRMAX.LE.ELIST(ISUCC)) GO TO 60                             PMT45790
         IORD(NRMAX) = ISUCC                                              PMT45800
         NRMAX = NRMAX - 1                                                PMT45810
   40 CONTINUE                                                            PMT45820
C                                                                         PMT45830
C           COMPUTE THE NUMBER OF ELEMENTS IN THE LIST TO                 PMT45840
C           BE MAINTAINED IN DESCENDING ORDER. THIS NUMBER                PMT45850
C           DEPENDS ON THE NUMBER OF SUBDIVISIONS STILL                   PMT45860
C           ALLOWED                                                       PMT45870
C                                                                         PMT45880
   60 JUPBND = LAST                                                       PMT45890
      IF (LAST.GT.(LIMIT/2+2)) JUPBND = LIMIT + 3 - LAST                  PMT45900
      ERRMIN = ELIST(LAST)                                                PMT45910
```

```
C                                                                       PMT45920
C           INSERT ERRMAX BY TRAVERSING THE LIST TOP-DOWN               PMT45930
C           STARTING COMPARISON FROM THE ELEMENT                        PMT45940
C           ELIST(IORD(NRMAX+1))                                        PMT45950
C                                                                       PMT45960
      JBND = JUPBND - 1                                                 PMT45970
      IBEG = NRMAX + 1                                                  PMT45980
      IF (IBEG.GT.JBND) GO TO 100                                       PMT45990
      DO 80 I=IBEG,JBND                                                 PMT46000
         ISUCC = IORD(I)                                                PMT46010
         IF (ERRMAX.GE.ELIST(ISUCC)) GO TO 120                          PMT46020
         IORD(I-1) = ISUCC                                              PMT46030
   80 CONTINUE                                                          PMT46040
  100 IORD(JBND) = MAXERR                                               PMT46050
      IORD(JUPBND) = LAST                                               PMT46060
      GO TO 180                                                         PMT46070
C                                                                       PMT46080
C           INSERT ERRMIN BY TRAVERSING THE LIST BOTTOM-UP              PMT46090
C                                                                       PMT46100
  120 IORD(I-1) = MAXERR                                                PMT46110
      K = JBND                                                          PMT46120
      DO 140 J=I,JBND                                                   PMT46130
         ISUCC = IORD(K)                                                PMT46140
         IF (ERRMIN.LT.ELIST(ISUCC)) GO TO 160                          PMT46150
         IORD(K+1) = ISUCC                                              PMT46160
         K = K - 1                                                      PMT46170
  140 CONTINUE                                                          PMT46180
      IORD(I) = LAST                                                    PMT46190
      GO TO 180                                                         PMT46200
  160 IORD(K+1) = LAST                                                  PMT46210
C                                                                       PMT46220
C           SET MAXERR AND ERMAX                                        PMT46230
C                                                                       PMT46240
  180 MAXERR = IORD(NRMAX)                                              PMT46250
      ERMAX = ELIST(MAXERR)                                             PMT46260
      RETURN                                                            PMT46270
      END                                                               PMT46280
C
C                                                                       PMT46290
C                                                                       PMT46300
      SUBROUTINE D01AJY(N, EPSTAB, RESULT, ABSERR, RES3LA, NRES)        PMT46310
C                    SUBROUTINE D01AJY , PART OF PEM-2 (VERSION 84130)..PMT46320
C                                                                       PMT46330
C     MARK 8 RELEASE. NAG COPYRIGHT 1979                                PMT46340
C     BASED ON QUADPACK ROUTINE EPSALG                                  PMT46350
C     ****************************************************              PMT46360
C                                                                       PMT46370
C           PURPOSE                                                     PMT46380
C              THE ROUTINE TRANSFORMS A GIVEN SEQUENCE OF               PMT46390
C              APPROXIMATIONS, BY MEANS OF THE EPSILON                  PMT46400
C              ALGORITHM OF P. WYNN.                                    PMT46410
C                                                                       PMT46420
C              AN ESTIMATE OF THE ABSOLUTE ERROR IS ALSO GIVEN.         PMT46430
C              THE CONDENSED EPSILON TABLE IS COMPUTED. ONLY THOSE      PMT46440
C              ELEMENTS NEEDED FOR THE COMPUTATION OF THE               PMT46450
C              NEXT DIAGONAL ARE PRESERVED.                             PMT46460
C                                                                       PMT46470
C           CALLING SEQUENCE                                            PMT46480
C              CALL D01AJY (N,EPSTAB,RESULT,ABSERR,RES3LA,NRES)         PMT46490
C                                                                       PMT46500
C           PARAMETERS                                                  PMT46510
C              N      - EPSTAB(N) CONTAINS THE NEW ELEMENT IN THE       PMT46520
C                       FIRST COLUMN OF THE EPSILON TABLE.              PMT46530
C                                                                       PMT46540
C              EPSTAB - ONE DIMENSIONAL ARRAY CONTAINING THE            PMT46550
C                       ELEMENTS OF THE TWO LOWER DIAGONALS OF          PMT46560
C                       THE TRIANGULAR EPSILON TABLE.                   PMT46570
C                       THE ELEMENTS ARE NUMBERED STARTING AT THE       PMT46580
C                       RIGHT-HAND CORNER OF THE TRIANGLE.              PMT46590
C                       THE DIMENSION SHOULD BE AT LEAST N+2.           PMT46600
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C                                                                       PMT46610
C             RESULT - RESULTING APPROXIMATION TO THE INTEGRAL          PMT46620
C                                                                       PMT46630
C             ABSERR - ESTIMATE OF THE ABSOLUTE ERROR COMPUTED FROM     PMT46640
C                      RESULT AND THE 3 PREVIOUS /RESULTS/              PMT46650
C                                                                       PMT46660
C             RES3LA - ARRAY CONTAINING THE LAST 3 /RESULTS/            PMT46670
C                                                                       PMT46680
C             NRES   - NUMBER OF CALLS TO THE ROUTINE                   PMT46690
C                      (SHOULD BE ZERO AT FIRST CALL)                   PMT46700
C                                                                       PMT46710
C     ***************************************************               PMT46720
C     .. SCALAR ARGUMENTS ..                                            PMT46730
      DOUBLE PRECISION ABSERR, RESULT                                   PMT46740
      INTEGER N, NRES                                                   PMT46750
C     .. ARRAY ARGUMENTS ..                                             PMT46760
      DOUBLE PRECISION EPSTAB(52), RES3LA(3)                            PMT46770
C     ..                                                                PMT46780
C     .. LOCAL SCALARS ..                                               PMT46790
      DOUBLE PRECISION DELTA1, DELTA2, DELTA3, E0, E1, E1ABS, E2, E3,   PMT46800
     * EPMACH,EPSINF, ERR1, ERR2, ERR3, ERROR, OFLOW, RES, SS, TOL1,    PMT46810
     * TOL2,TOL3                                                        PMT46820
      INTEGER I, IB2, IB, IE, IND, K1, K2, K3, LIMEXP, NEWELM, NUM      PMT46830
C     .. FUNCTION REFERENCES ..                                         PMT46840
      DOUBLE PRECISION X02AAF, X02ACF                                   PMT46850
C     ..                                                                PMT46860
C                                                                       PMT46870
C            MACHINE DEPENDENT CONSTANTS                                PMT46880
C             -------------------------                                 PMT46890
C            /LIMEXP/ IS THE MAXIMUM NUMBER OF ELEMENTS THE EPSILON     PMT46900
C            TABLE CAN CONTAIN. IF THIS NUMBER IS REACHED, THE UPPER    PMT46910
C            DIAGONAL OF THE EPSILON TABLE IS DELETED.                  PMT46920
C                                                                       PMT46930
      DATA LIMEXP /50/                                                  PMT46940
      EPMACH = X02AAF()                                                 PMT46950
      OFLOW = X02ACF()                                                  PMT46960
C                                                                       PMT46970
C           LIST OF MAJOR VARIABLES                                     PMT46980
C           -----------------------                                     PMT46990
C           E0     - THE 4 ELEMENTS ON WHICH THE                        PMT47000
C           E1       COMPUTATION OF A NEW ELEMENT IN                    PMT47010
C           E2       THE EPSILON TABLE IS BASED                         PMT47020
C           E3                  E0                                      PMT47030
C                        E3     E1     NEW                              PMT47040
C                               E2                                      PMT47050
C           NEWELM - NUMBER OF ELEMENTS TO BE COMPUTED IN THE NEW       PMT47060
C                    DIAGONAL                                           PMT47070
C           ERROR  - ERROR = ABS(E1-E0)+ABS(E2-E1)+ABS(NEW-E2)          PMT47080
C           RESULT - THE ELEMENT IN THE NEW DIAGONAL WITH LEAST         PMT47090
C                    ERROR                                              PMT47100
C                                                                       PMT47110
      NRES = NRES + 1                                                   PMT47120
      ABSERR = OFLOW                                                    PMT47130
      RESULT = EPSTAB(N)                                                PMT47140
      IF (N.LT.3) GO TO 200                                             PMT47150
      EPSTAB(N+2) = EPSTAB(N)                                           PMT47160
      NEWELM = (N-1)/2                                                  PMT47170
      EPSTAB(N) = OFLOW                                                 PMT47180
      NUM = N                                                           PMT47190
      K1 = N                                                            PMT47200
      DO 80 I=1,NEWELM                                                  PMT47210
         K2 = K1 - 1                                                    PMT47220
         K3 = K1 - 2                                                    PMT47230
         RES = EPSTAB(K1+2)                                             PMT47240
         E0 = EPSTAB(K3)                                                PMT47250
         E1 = EPSTAB(K2)                                                PMT47260
         E2 = RES                                                       PMT47270
         E1ABS = DABS(E1)                                               PMT47280
         DELTA2 = E2 - E1                                               PMT47290
         ERR2 = DABS(DELTA2)                                            PMT47300
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      TOL2 = DMAX1(DABS(E2),E1ABS)*EPMACH                               PMT47310
      DELTA3 = E1 - E0                                                  PMT47320
      ERR3 = DABS(DELTA3)                                               PMT47330
      TOL3 = DMAX1(E1ABS,DABS(E0))*EPMACH                               PMT47340
      IF (ERR2.GT.TOL2 .OR. ERR3.GT.TOL3) GO TO 20                      PMT47350
C                                                                       PMT47360
C        IF E0, E1 AND E2 ARE EQUAL TO WITHIN MACHINE                   PMT47370
C        ACCURACY, CONVERGENCE IS ASSUMED                               PMT47380
C        RESULT = E2                                                    PMT47390
C        ABSERR = ABS(E1-E0)+ABS(E2-E1)                                 PMT47400
C                                                                       PMT47410
      RESULT = RES                                                      PMT47420
      ABSERR = ERR2 + ERR3                                              PMT47430
      GO TO 200                                                         PMT47440
   20 E3 = EPSTAB(K1)                                                   PMT47450
      EPSTAB(K1) = E1                                                   PMT47460
      DELTA1 = E1 - E3                                                  PMT47470
      ERR1 = DABS(DELTA1)                                               PMT47480
      TOL1 = DMAX1(E1ABS,DABS(E3))*EPMACH                               PMT47490
C                                                                       PMT47500
C        IF TWO ELEMENTS ARE VERY CLOSE TO EACH OTHER, OMIT             PMT47510
C        A PART OF THE TABLE BY ADJUSTING THE VALUE OF N                PMT47520
C                                                                       PMT47530
      IF (ERR1.LT.TOL1 .OR. ERR2.LT.TOL2 .OR. ERR3.LT.TOL3) GOTO 40     PMT47540
      SS = 0.1D+01/DELTA1 + 0.1D+01/DELTA2 - 0.1D+01/DELTA3             PMT47550
      EPSINF = DABS(SS*E1)                                              PMT47560
C                                                                       PMT47570
C        TEST TO DETECT IRREGULAR BEHAVIOUR IN THE TABLE, AND           PMT47580
C        EVENTUALLY OMIT A PART OF THE TABLE ADJUSTING THE VALUE        PMT47590
C        OF N                                                           PMT47600
C                                                                       PMT47610
      IF (EPSINF.GT.0.1D-03) GO TO 60                                   PMT47620
   40 N = I + I - 1                                                     PMT47630
      GO TO 100                                                         PMT47640
C                                                                       PMT47650
C        COMPUTE A NEW ELEMENT AND EVENTUALLY ADJUST                    PMT47660
C        THE VALUE OF RESULT                                            PMT47670
C                                                                       PMT47680
   60 RES = E1 + 0.1D+01/SS                                             PMT47690
      EPSTAB(K1) = RES                                                  PMT47700
      K1 = K1 - 2                                                       PMT47710
      ERROR = ERR2 + DABS(RES-E2) + ERR3                                PMT47720
      IF (ERROR.GT.ABSERR) GO TO 80                                     PMT47730
      ABSERR = ERROR                                                    PMT47740
      RESULT = RES                                                      PMT47750
   80 CONTINUE                                                          PMT47760
C                                                                       PMT47770
C        SHIFT THE TABLE                                                PMT47780
C                                                                       PMT47790
  100 IF (N.EQ.LIMEXP) N = 2*(LIMEXP/2) - 1                             PMT47800
      IB = 1                                                            PMT47810
      IF ((NUM/2)*2.EQ.NUM) IB = 2                                      PMT47820
      IE = NEWELM + 1                                                   PMT47830
      DO 120 I=1,IE                                                     PMT47840
         IB2 = IB + 2                                                   PMT47850
         EPSTAB(IB) = EPSTAB(IB2)                                       PMT47860
         IB = IB2                                                       PMT47870
  120 CONTINUE                                                          PMT47880
      IF (NUM.EQ.N) GO TO 160                                           PMT47890
      IND = NUM - N + 1                                                 PMT47900
      DO 140 I=1,N                                                      PMT47910
         EPSTAB(I) = EPSTAB(IND)                                        PMT47920
         IND = IND + 1                                                  PMT47930
  140 CONTINUE                                                          PMT47940
  160 IF (NRES.GE.4) GO TO 180                                          PMT47950
      RES3LA(NRES) = RESULT                                             PMT47960
      ABSERR = OFLOW                                                    PMT47970
      GO TO 200                                                         PMT47980
C                                                                       PMT47990
C        COMPUTE ERROR ESTIMATE                                         PMT48000
```

```
C
  180 ABSERR = DABS(RESULT-RES3LA(3)) + DABS(RESULT-RES3LA(2)) +
     *DABS(RESULT-RES3LA(1))
      RES3LA(1) = RES3LA(2)
      RES3LA(2) = RES3LA(3)
      RES3LA(3) = RESULT
  200 ABSERR = DMAX1(ABSERR,5.0D+00*EPMACH*DABS(RESULT))
      RETURN
      END
C
C
C
      SUBROUTINE D01AJZ(F, A, B, RESULT, ABSERR, RESABS, RESASC)
C                 SUBROUTINE D01AJZ , PART OF PEM-2 (VERSION 84130).
C
C     MARK 8 RELEASE. NAG COPYRIGHT 1979
C     BASED ON QUADPACK ROUTINE QUARUL
C     ****************************************************
C
C           PURPOSE
C              TO COMPUTE I = INTEGRAL OF F OVER (A,B), WITH ERROR
C                             ESTIMATE
C                         J = INTEGRAL OF ABS(F) OVER (A,B)
C
C           CALLING SEQUENCE
C              CALL D01AJZ (F,A,B,RESULT,ABSERR,RESABS,RESASC)
C
C           PARAMETERS
C              F      - FUNCTION SUBPROGRAM DEFINING THE INTEGRAND
C                       FUNCTION F(X). THE ACTUAL NAME FOR F NEEDS
C                       TO BE DECLARED E X T E R N A L IN THE
C                       CALLING PROGRAM
C
C              A      - LOWER LIMIT OF INTEGRATION
C
C              B      - UPPER LIMIT OF INTEGRATION
C
C              RESULT - APPROXIMATION TO THE INTEGRAL I.
C                       RESULT IS CALCULATED BY APPLYING
C                       THE 21-POINT GAUSS-KRONROD RULE
C                       (RESK), OBTAINED BY OPTIMAL
C                       ADDITION OF ABSCISSAE TO THE
C                       10-POINT GAUSS  RULE (RESG).
C
C              ABSERR - ESTIMATE OF THE MODULUS OF THE
C                       ABSOLUTE ERROR, WHICH SHOULD NOT
C                       EXCEED ABS(I-RESULT)
C              RESABS - APPROXIMATION TO THE INTEGRAL J
C
C              RESASC - APPROXIMATION TO THE INTEGRAL OF
C                       ABS(F-I/(B-A)) OVER (A,B)
C
C     ****************************************************
C     .. SCALAR ARGUMENTS ..
      DOUBLE PRECISION A, ABSERR, B, RESABS, RESASC, RESULT
C     .. FUNCTION ARGUMENTS ..
      DOUBLE PRECISION F
C     ..
C     .. LOCAL SCALARS ..
      DOUBLE PRECISION ABSC, CENTRE, DHLGTH, EPMACH, FC, FSUM, FVAL1,
     * FVAL2,HLGTH, RESG, RESK, RESKH, UFLOW
      INTEGER J
C     .. LOCAL ARRAYS ..
      DOUBLE PRECISION FV1(10), FV2(10), WG(10), WGK(11), XGK(11)
C     .. FUNCTION REFERENCES ..
      DOUBLE PRECISION X02AAF, X02ABF
C     ..
C
C            THE ABSCISSAE AND WEIGHTS ARE GIVEN FOR THE
C            INTERVAL (-1,1) . BECAUSE OF SYMMETRY ONLY THE
```

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C           POSITIVE ABSCISSAE AND THEIR CORRESPONDING                  PMT48700
C           WEIGHTS ARE GIVEN.                                          PMT48710
C           XGK    - ABSCISSAE OF THE 21-POINT GAUSS-KRONROD RULE       PMT48720
C                    XGK(2), XGK(4), .... ABSCISSAE OF THE 10-POINT     PMT48730
C                    GAUSS RULE                                         PMT48740
C                    XGK(1), XGK(3), .... ABSCISSAE WHICH               PMT48750
C                    ARE OPTIMALLY ADDED TO THE 10-POINT                PMT48760
C                    GAUSS RULE                                         PMT48770
C           WGK    - WEIGHTS OF THE 21-POINT GAUSS-KRONROD RULE         PMT48780
C           WG     - WEIGHTS OF THE 10-POINT GAUSS RULE,                PMT48790
C                    CORRESPONDING TO THE ABSCISSAE XGK(2),             PMT48800
C                    XGK(4), ... WG(1), WG(3), ... ARE SET              PMT48810
C                    TO ZERO.                                           PMT48820
C                                                                       PMT48830
      DATA XGK(1), XGK(2), XGK(3), XGK(4), XGK(5), XGK(6), XGK(7),XGK(8)PMT48840
     *, XGK(9), XGK(10), XGK(11) /0.995657163025808080735527280 7D+00,  PMT48850
     *0.9739065285171717200779640121D+00,                               PMT48860
     *0.9301574913557082260012071801D+00,                               PMT48870
     *0.8650633666889845107320966884D+00,                               PMT48880
     *0.7808177265864168970637175783D+00,                               PMT48890
     *0.6794095682990244062343273651D+00,                               PMT48900
     *0.5627571346860468333900009 93D+00,                               PMT48910
     *0.4333953941292471907992659432D+00,                               PMT48920
     *0.2943928627014601981311266031D+00,                               PMT48930
     *0.1488743389816312108848260011D+00,0.0D0/                         PMT48940
      DATA WGK(1), WGK(2), WGK(3), WGK(4), WGK(5), WGK(6), WGK(7),WGK(8)PMT48950
     *, WGK(9), WGK(10), WGK(11) /0.116946388673718742780643960 6D-01,  PMT48960
     *0.3255816230796472747881897246D-01,                               PMT48970
     *0.5475589657435199603138130024D-01,                               PMT48980
     *0.7503967481091995276704314092D-01,                               PMT48990
     *0.9312545458369760553506546508D-01,                               PMT49000
     *0.1093871588022976418992105903D+00,                               PMT49010
     *0.1234919762620658510779581098D+00,                               PMT49020
     *0.1347092173114733259280540018D+00,                               PMT49030
     *0.1427759385770600807970942731D+00,                               PMT49040
     *0.1477391049013384913748415160D+00,                               PMT49050
     *0.1494455540029169056649364684D+00/                               PMT49060
      DATA WG(1), WG(2), WG(3), WG(4), WG(5), WG(6), WG(7), WG(8),WG(9),PMT49070
     * WG(10) /0.0D0,0.6667134430868813759356880989D-01,0.0D0,          PMT49080
     *0.1494513491505805931457763397D+00,0.0D0,                         PMT49090
     *0.2190863625159820439955349342D+00,0.0D0,                         PMT49100
     *0.2692667193099963550912269216D+00,0.0D0,                         PMT49110
     *0.2955242247147528701738929947D+00/                               PMT49120
      EPMACH = X02AAF()                                                 PMT49130
      UFLOW = X02ABF()                                                  PMT49140
C                                                                       PMT49150
C           LIST OF MAJOR VARIABLES                                     PMT49160
C           -----------------------                                     PMT49170
C           CENTRE - MID POINT OF THE INTERVAL                          PMT49180
C           HLGTH  - HALF LENGTH OF THE INTERVAL                        PMT49190
C           ABSC   - ABSCISSA                                           PMT49200
C           FVAL*  - FUNCTION VALUE                                     PMT49210
C           RESG   - 10-POINT GAUSS FORMULA                             PMT49220
C           RESK   - 21-POINT GAUSS-KRONROD FORMULA                     PMT49230
C           RESKH  - APPROXIMATION TO MEAN VALUE OF F OVER              PMT49240
C                    (A,B), I.E. TO I/(B-A)                             PMT49250
C                                                                       PMT49260
      CENTRE = 0.5D+00*(A+B)                                            PMT49270
      HLGTH = 0.5D+00*(B-A)                                             PMT49280
      DHLGTH = DABS(HLGTH)                                              PMT49290
C                                                                       PMT49300
C           COMPUTE THE 21-POINT GAUSS-KRONROD APPROXIMATION TO         PMT49310
C           THE INTEGRAL, AND ESTIMATE THE ABSOLUTE ERROR               PMT49320
C                                                                       PMT49330
      RESG = 0.0D+00                                                    PMT49340
      FC = F(CENTRE)                                                    PMT49350
      RESK = WGK(11)*FC                                                 PMT49360
      RESABS = DABS(RESK)                                               PMT49370
      DO 20 J=1,10                                                      PMT49380
         ABSC = HLGTH*XGK(J)                                            PMT49390
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```
         FVAL1 = F(CENTRE-ABSC)                                         PMT49400
         FVAL2 = F(CENTRE+ABSC)                                         PMT49410
         FV1(J) = FVAL1                                                 PMT49420
         FV2(J) = FVAL2                                                 PMT49430
         FSUM = FVAL1 + FVAL2                                           PMT49440
         RESG = RESG + WG(J)*FSUM                                       PMT49450
         RESK = RESK + WGK(J)*FSUM                                      PMT49460
         RESABS = RESABS + WGK(J)*(DABS(FVAL1)+DABS(FVAL2))             PMT49470
   20 CONTINUE                                                          PMT49480
      RESKH = RESK*0.5D+00                                              PMT49490
      RESASC = WGK(11)*DABS(FC-RESKH)                                   PMT49500
      DO 40 J=1,10                                                      PMT49510
         RESASC = RESASC + WGK(J)*(DABS(FV1(J)-RESKH)+DABS(FV2(J)-RESKH)PMT49520
     *   )                                                              PMT49530
   40 CONTINUE                                                          PMT49540
      RESULT = RESK*HLGTH                                               PMT49550
      RESABS = RESABS*DHLGTH                                            PMT49560
      RESASC = RESASC*DHLGTH                                            PMT49570
      ABSERR = DABS((RESK-RESG)*HLGTH)                                  PMT49580
      IF (RESASC.NE.0.D+00) ABSERR = RESASC*DMIN1(0.1D+01,(0.2D+03*     PMT49590
     *ABSERR/RESASC)**1.5D0)                                            PMT49600
      IF (RESABS.GT.UFLOW/(0.5D+02*EPMACH)) ABSERR =DMAX1(EPMACH*RESABS*PMT49610
     *0.5D+02,ABSERR)                                                   PMT49620
      RETURN                                                            PMT49630
      END                                                               PMT49640
C
C                                                                       PMT49650
C                                                                       PMT49660
      INTEGER FUNCTION P01AAF(IFAIL, ERROR, SRNAME)                     PMT49670
C                     FUNCTION P01AAF , PART OF PEM-2 (VERSION 84130). PMT49680
C                                                                       PMT49690
C     MARK 1 RELEASE.  NAG COPYRIGHT 1971                               PMT49700
C     MARK 3 REVISED                                                    PMT49710
C     MARK 4A REVISED, IER-45                                           PMT49720
C     MARK 4.5 REVISED                                                  PMT49730
C     MARK 7 REVISED (DEC 1978)                                         PMT49740
C     RETURNS THE VALUE OF ERROR OR TERMINATES THE PROGRAM.             PMT49750
      INTEGER ERROR, IFAIL, NOUT                                        PMT49760
C$P 1                                                                   PMT49770
      DOUBLE PRECISION SRNAME                                           PMT49780
C     TEST IF NO ERROR DETECTED                                         PMT49790
      IF (ERROR.EQ.0) GO TO 20                                          PMT49800
C     DETERMINE OUTPUT UNIT FOR MESSAGE                                 PMT49810
      CALL X04AAF (0,NOUT)                                              PMT49820
C     TEST FOR SOFT FAILURE                                             PMT49830
      IF (MOD(IFAIL,10).EQ.1) GO TO 10                                  PMT49840
C     HARD FAILURE                                                      PMT49850
      WRITE (NOUT,99999) SRNAME, ERROR                                  PMT49860
C     STOPPING MECHANISM MAY ALSO DIFFER                                PMT49870
      CALL WAUDIT
      STOP                                                              PMT49880
C     SOFT FAIL                                                         PMT49890
C     TEST IF ERROR MESSAGES SUPPRESSED                                 PMT49900
   10 IF (MOD(IFAIL/10,10).EQ.0) GO TO 20                               PMT49910
      WRITE (NOUT,99999) SRNAME, ERROR                                  PMT49920
   20 P01AAF = ERROR                                                    PMT49930
      RETURN                                                            PMT49940
99999 FORMAT (1H0, 38HERROR DETECTED BY NAG LIBRARY ROUTINE , A8,       PMT49950
     * 11H - IFAIL = , I5//)                                            PMT49960
      END                                                               PMT49970
C
C                                                                       PMT49980
C                                                                       PMT49990
      DOUBLE PRECISION FUNCTION X02AAF()                                PMT50000
C                     FUNCTION X02AAF , PART OF PEM-2 (VERSION 84130). PMT50010
C                                                                       PMT50020
C     NAG COPYRIGHT 1975                                                PMT50030
C     MARK 4.5 RELEASE                                                  PMT50040
C                                                                       PMT50050
C     * EPS *                                                           PMT50060
```

```
C                                                                       PMT50070
C     UNIVAC DOUBLE PRECISION VERSION                                   PMT50080
C                                                                       PMT50090
C     RETURNS THE VALUE EPS WHERE EPS IS THE SMALLEST POSITIVE          PMT50100
C     NUMBER SUCH THAT 1.0 + EPS > 1.0                                  PMT50120
C                                                                       PMT50130
C     FOR ICL 1900                                                      PMT50140
C     X02AAF = 2.0**(-37.0)                                             PMT50150
C                                                                       PMT50155
C     FOR IBM 360/370                                                   PMT50160
C     X02AAF = 2.0D0**(-52.0D0)                                         PMT50170
C                                                                       PMT50175
      DOUBLE PRECISION Z                                                PMT50180
C                                                                       PMT50185
C     FOR IBM-3033                                                      PMT50190
C     DATA Z/Z3410000000000000/                                         PMT50200
C                                                                       PMT50205
C     FOR UNIVAC-1100                                                   PMT50210
      DIMENSION ZZ(2)                                                   PMT50220
      EQUIVALENCE (ZZ(1),Z)                                             PMT50230
      DATA ZZ /0171410000000,0000000000000/                             PMT50240
      X02AAF = Z                                                        PMT50250
      RETURN                                                            PMT50260
      END                                                               PMT50270
C
C                                                                       PMT50280
C                                                                       PMT50290
      DOUBLE PRECISION FUNCTION X02ABF()                                PMT50300
C                      FUNCTION X02ABF , PART OF PEM-2 (VERSION 84130). PMT50310
C                                                                       PMT50320
C     NAG COPYRIGHT 1975                                                PMT50330
C     MARK 4.5 RELEASE                                                  PMT50340
C                                                                       PMT50350
C     * RMIN *                                                          PMT50360
C                                                                       PMT50370
C     UNIVAC DOUBLE PRECISION VERSION                                   PMT50380
C                                                                       PMT50390
C     RETURNS THE VALUE OF THE SMALLEST POSITIVE REAL FLOATING-         PMT50400
C     POINT NUMBER EXACTLY REPRESENTABLE ON THE COMPUTER                PMT50410
C                                                                       PMT50420
C     FOR ICL 1900                                                      PMT50430
C     X02ABF = 2.0**(-257.0)                                            PMT50440
C                                                                       PMT50445
C     FOR IBM 360/370                                                   PMT50450
C     X02ABF = 16.0D0**(-65.0D0)                                        PMT50460
C                                                                       PMT50465
      DOUBLE PRECISION Z                                                PMT50470
C                                                                       PMT50475
C     FOR IBM-3033                                                      PMT50480
C     DATA Z/Z0010000000000000/                                         PMT50490
C                                                                       PMT50495
C     FOR UNIVAC-1100                                                   PMT50500
      DIMENSION ZZ(2)                                                   PMT50510
      EQUIVALENCE (ZZ(1),Z)                                             PMT50520
      DATA ZZ /0000110000000,0000000000000/                             PMT50530
      X02ABF = Z                                                        PMT50540
      RETURN                                                            PMT50550
      END                                                               PMT50560
C
C                                                                       PMT50570
C                                                                       PMT50580
      DOUBLE PRECISION FUNCTION X02ACF()                                PMT50590
C                      FUNCTION X02ACF , PART OF PEM-2 (VERSION 84130). PMT50600
C                                                                       PMT50610
C     NAG COPYRIGHT 1975                                                PMT50620
C     MARK 4.5 RELEASE                                                  PMT50630
C                                                                       PMT50640
C     * RMAX *                                                          PMT50650
C                                                                       PMT50660
C     UNIVAC DOUBLE PRECISION VERSION                                   PMT50670
```

```
C
C     RETURNS THE VALUE OF THE LARGEST POSITIVE REAL  FLOATING-
C     POINT NUMBER REPRESENTABLE ON THE COMPUTER
C
C     FOR ICL 1900
C     X02ACF = (2.0 - 2.0**(-36.0))*2.0**254.0
C
C     FOR IBM 360/370
C     X02ACF = (1.0D0-16.0D0**(-14.0D0))*16.0D0**63.0D0
C
      DOUBLE PRECISION Z
C
C     FOR IBM-3033
C     DATA Z/Z7FFFFFFFFFFFFFFF/
C
C     FOR UNIVAC-1100
      DIMENSION ZZ(2)
      EQUIVALENCE (ZZ(1),Z)
      DATA ZZ /0377777777777,0777777777777/
      X02ACF = Z
      RETURN
      END
C
C
C
      SUBROUTINE X04AAF(I,NERR)
C                    SUBROUTINE X04AAF , PART OF PEM-2 (VERSION 84130).
C
C     MARK 7 RELEASE. NAG COPYRIGHT 1978
C     MARK 7C REVISED IER-190 (MAY 1979)
C     IF I = 0, SETS NERR TO CURRENT ERROR MESSAGE UNIT NUMBER
C     (STORED IN NERR1).
C     IF I = 1, CHANGES CURRENT ERROR MESSAGE UNIT NUMBER TO
C     VALUE SPECIFIED BY NERR.
C
C     *** NOTE ***
C     THIS ROUTINE ASSUMES THAT THE VALUE OF NERR1 IS SAVED
C     BETWEEN CALLS.  IN SOME IMPLEMENTATIONS IT MAY BE
C     NECESSARY TO STORE NERR1 IN A LABELLED COMMON
C     BLOCK /AX04AA/ TO ACHIEVE THIS.
C
C     .. SCALAR ARGUMENTS ..
      INTEGER I, NERR
C     ..
C     .. LOCAL SCALARS ..
      INTEGER NERR1
C     ..
      DATA NERR1 /6/
      IF (I.EQ.0) NERR = NERR1
      IF (I.EQ.1) NERR1 = NERR
      RETURN
      END
C
      SUBROUTINE WIND(UA,PWR,HQ,UPL)
C                  SUBROUTINE WIND   , PART OF PEM-2 (VERSION 84130)
C
C
C  SUBROUTINE WIND DETERMINES THE WIND SPEED AT SOURCE HEIGHT
C   ACCORDING TO THE WIND PROFILE POWER LAW.
C
C    UA = ANEMOMETER WIND SPEED (M/S)
C    PWR = EXPONENT OF POWER LAW WIND PROFILE
C    HQ = SOURCE HEIGHT (M)
C    UPL = OUTPUT WIND SPEED AT SOURCE HEIGHT (M/S)
C    HA = ANEMOMETER HEIGHT (M)
C    HMIN = WIND SPEED HELD CONSTANT BELOW THIS HEIGHT (M)
C    HMAX = WIND SPEED CONSTANT ABOVE THIS HEIGHT (M)
C    UMIN = WIND SPEED NOT ALLOWED LESS THAN THIS VALUE (M/S)
C
C    IUFLG = WIND SPEED FLAG INDICATOR
```

```
C       0  -  NORMAL COMPUTATION                                        PMT51310
C       1  -  WIND SPEED SET AT VALUE AT HMIN                           PMT51320
C       2  -  WIND SPEED SET AT VALUE AT HMAX                           PMT51330
C       3  -  WIND SPEED SET AT UMIN VALUE                              PMT51340
C                                                                       PMT51350
C                                                                       PMT51360
      COMMON/PARM7A/HA,P1(6)                                            PMT51370
      COMMON/WND/HMIN,HMAX,UMIN,IUFLG                                   PMT51380
C                                                                       PMT51390
C     DEFAULT VALUES FOR HA, HMIN, HMAX, AND UMIN WERE SET              PMT51400
C     IN SUBROUTINE INMOD AS 10., 10., 200., AND 1. RESPECTIVELY,       PMT51410
C     UNLESS DEFINED ON THE INPUT CARD #7.                              PMT51420
C                                                                       PMT51430
      IF(HQ.LT.HMAX) THEN                                               PMT51440
      IF(HQ.GT.HMIN) THEN                                               PMT51450
      UPL=UA*((HQ/HA)**PWR)                                             PMT51460
      IUFLG=0                                                           PMT51470
      ELSE                                                              PMT51480
      UPL=UA*((HMIN/HA)**PWR)                                           PMT51490
      IUFLG=1                                                           PMT51500
      END IF                                                            PMT51510
      ELSE                                                              PMT51520
      UPL=UA*((HMAX/HA)**PWR)                                           PMT51530
      IUFLG=2                                                           PMT51540
      END IF                                                            PMT51550
      IF(UPL.LT.UMIN) THEN                                              PMT51560
      UPL=UMIN                                                          PMT51570
      IUFLG=3                                                           PMT51580
      END IF                                                            PMT51590
      RETURN                                                            PMT51600
      END                                                               PMT51610
```

```
C       0  -  NORMAL COMPUTATION                                          PMT51310
C       1  -  WIND SPEED SET AT VALUE AT HMIN                             PMT51320
C       2  -  WIND SPEED SET AT VALUE AT HMAX                             PMT51330
C       3  -  WIND SPEED SET AT UMIN VALUE                                PMT51340
C                                                                         PMT51350
C                                                                         PMT51360
      COMMON/PARM7A/HA,P1(6)                                              PMT51370
      COMMON/WND/HMIN,HMAX,UMIN,IUFLG                                     PMT51380
C                                                                         PMT51390
C     DEFAULT VALUES FOR HA, HMIN, HMAX, AND UMIN WERE SET                PMT51400
C     IN SUBROUTINE INMOD AS 10., 10., 200., AND 1. RESPECTIVELY,         PMT51410
C     UNLESS DEFINED ON THE INPUT CARD #7.                                PMT51420
C                                                                         PMT51430
      IF(HQ.LT.HMAX) THEN                                                 PMT51440
      IF(HQ.GT.HMIN) THEN                                                 PMT51450
      UPL=UA*((HQ/HA)**PWR)                                               PMT51460
      IUFLG=0                                                             PMT51470
      ELSE                                                                PMT51480
      UPL=UA*((HMIN/HA)**PWR)                                             PMT51490
      IUFLG=1                                                             PMT51500
      END IF                                                              PMT51510
      ELSE                                                                PMT51520
      UPL=UA*((HMAX/HA)**PWR)                                             PMT51530
      IUFLG=2                                                             PMT51540
      END IF                                                              PMT51550
      IF(UPL.LT.UMIN) THEN                                                PMT51560
      UPL=UMIN                                                            PMT51570
      IUFLG=3                                                             PMT51580
      END IF                                                              PMT51590
      RETURN                                                              PMT51600
      END                                                                 PMT51610
```

Date _____

Return form to;

James M. Godowitch
Meteorology and Assessment Division (MD-80)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I wish to receive future revisions to the
PEM-2 User Guide.

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