DOCUMENTATION OF A GRAPHICAL DISPLAY PROGRAM FOR THE SATURATED-UNSATURATED TRANSPORT (SUTRA) FINITE-ELEMENT SIMULATION MODEL

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CONVERSION TABLE

The following table may be used to convert measurements in inch-pound units to metric (International System) units (SI).

Multiply inch-pound unit	By	To obtain metric unit
	Temperature	
degree Fahrenheit (°F)	°C = 5/9 (°F-32)	degree Celsius (°C)
	Length	
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
	Velocity	
foot per day (ft/d)	3.528×10^{-6}	meter per second (m/s)
	Pressure	
pound per square inch (lb/in^2)	0.006895	Pascal (Pa)

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DOCUMENTATION OF A GRAPHICAL DISPLAY PROGRAM FOR THE SATURATED-UNSATURATED TRANSPORT (SUTRA) FINITE-ELEMENT SIMULATION MODEL

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ABSTRACT

This report documents a graphical display program for the U.S. Geological Survey saturated-unsaturated transport (SUTRA) finite-element simulation model. Graphic features of the program, SUTRA-PLOT, include: 1) plots of the finite-element mesh, 2) velocity vector plots, 3) contour plots of pressure, solute concentration, temperature, or saturation, and 4) a finite-element interpolator for gridding data prior to contouring. SUTRA-PLOT is written in FORTRAN 77 on a PRIME 750 computer system, and requires Version 9.0 or higher of the DISSPLA graphics library.

The program requires two input files: the SUTRA input data list and the SUTRA simulation output listing. The program is menu driven and specifications for individual types of plots are entered and may be edited interactively. Installation instructions, a source code listing, and a description of the computer code are given. Six examples of plotting applications are used to demonstrate various features of the plotting program.

1. INTRODUCTION

The SUTRA-PLOT program produces a graphical display of simulation results from the U.S. Geological Survey finite-element ground-water flow and solute transport (SUTRA) model (Voss, 1984). The purpose of this report is to provide a users guide for running SUTRA-PLOT. The report also gives installation instructions and provides a description of the computer code to allow modification of the program for individual or specialized applications. A source code listing is included in Attachment E. Six examples of plotting applications are used to demonstrate various features of the plotting program.

SUTRA-PLOT uses subroutines from the DISSPLA graphics software package (Integrated Software Systems Corporation, 1984) for all output. Graphic features include: 1) plots of the finite-element mesh, 2) velocity vector plots, 3) contour plots of pressure, concentration, temperature, or saturation, and 4) a finite-element interpolator for gridding data prior to contouring.

The program is menu driven, and requires two input files: the SUTRA input data list and the SUTRA simulation output listing. Specifications for individual types of plots are entered and may be edited interactively at a user terminal. These specifications can be saved on a disk file for re-use, eliminating the need for re-entry of data from the keyboard. Output may be directed to any graphics device supported by DISSPLA or saved in a device-independent metafile.

The SUTRA-PLOT program was written in FORTRAN 77 on a PRIME 750 computer system, and requires Version 9.0 or higher of the DISSPLA graphics library. The program structure is modular to allow for the addition of new or more efficient methods of data manipulation. The program is designed and written specifically for SUTRA output. It could be easily modified, however, to read data from other finite-element models with a similar data structure.

SUTRA-PLOT is designed to provide quick, accurate graphical representation of output generated by the SUTRA model. It is not the intent of the program to produce publication quality graphics. The graphical output of the program does not necessarily conform to the publication standards of the U.S. Geological Survey

2. INSTALLING GRAPHICAL DISPLAY PROGRAM SUTRA-PLOT

The source code for SUTRA-PLOT is contained in the main program, V1086S.F77, and 20 subroutines. In addition, two utility programs SP_COMPILE.CPL and SP_LOAD.CPL are provided to compile, load and link the program to the PRIME FORTRAN library and DISSPLA library on PRIME computer systems. Once the program is initially compiled using SP_COMPILE.CPL, subroutines may be individually modified, separately compiled and the entire system re-loaded using SP_LOAD.CPL. SP_LOAD.CPL creates the executable segment directory, V1086S.SEG. Prior to compiling, however, two routines (V1086S.F77 and OUTDEV.F77) must be checked and, if necessary, modified as described below.

MAIN PROGRAM, V1086S.F77.--For the convenience of the user, the main program contains all of the arrays which must be dimensioned to allocate space according to the size of the SUTRA simulation. All of the vectors and arrays used by SUTRA-PLOT are combined into five large arrays which must be dimensioned by the user to values greater than or equal to the values described below. The variables and nomenclature used are the same as that used by the SUTRA model (Voss, 1984).

In the main program, five arrays, DPV, IMV, GV1, GV2, and IMG must be dimensioned on the basis of the size of the finite-element mesh used in the SUTRA simulation and the size of the contour gridding matrix, as follows:

```
DIMENSION DPV(DPVDIM), IMV(IMVDIM)
```

where:

```
DPVDIM >=  (3 * NN) + (3 * NE)
IMVDIM >=   5 * NE
```

and:

NN = number of nodes in finite element mesh
NE = number of elements in finite element mesh

```
DIMENSION GV1(IXDIM*IYDIM), GV2(IXDIM*IYDIM), IMG(IXDIM*IYDIM)
```

where:

IXDIM and IYDIM are the number of columns and number of rows, respectively, of the largest gridding matrix to be generated for contour plots (see Section 4.2 for an explanation of gridding as used in SUTRA-PLOT)

These relations and values are also listed in the main routine, V1086S.F77 and should be checked there for the most recent SUTRA-PLOT version.

Subroutine OUTDEV.F77.--This routine nominates the output graphics device and calls the appropriate device driver. This routine is installation dependent and must be modified to include DISSPLA calls to graphics devices available to the user. An example of a device nominating routine which is easily modified for other graphic devices is included in Attachment E. This subroutine otherwise may be replaced by any similar device nominating routine. The minimum requirement for OUTDEV is a single device call such as:

```
SUBROUTINE OUTDEV(IDEV)
CALL TAB
RETURN
```

3. RUNNING SUTRA-PLOT

Program execution can be started from any terminal by entering the PRIMOS command SEG V1086S. SUTRA-PLOT is designed to be used from a graphics terminal where the graphics output can be viewed and interactively changed. However, SUTRA-PLOT can be run from any type of terminal and, by programming subroutine OUTDEV, the graphic output can be directed to another device.

3.1 Input Data Files

At the start of the program, the user will be prompted for the filename of the SUTRA input data list. This file is the input data for SUTRA simulations designated UNIT 5 in the SUTRA documentation (Voss, 1984). The file must not have been modified in any way with respect to the SUTRA (Version V12842D) specifications. SUTRA-PLOT searches the file for finite-element mesh dimensions, node coordinates, and the nodal incidence list. Additionally, a check for the character string 'SUTRA' in the first six spaces of the first line is used to determine if the file is a valid input data list. If the correct character string is not present, the program will display an error message and prompt for another file name. If the file given cannot be successfully opened, the program will display an error message and prompt for another file name. Errors in opening the file generally are caused by entering incomplete pathnames, file names which do not exist, or files which are in use.

Prior to plotting, the program will additionally prompt for the name of the SUTRA output file that contains data to be plotted. The SUTRA output file is the printed results of a SUTRA simulation designated UNIT 6 in the SUTRA documentation. This file must not be modified. SUTRA-PLOT searches the file for time step information and specific character strings which identify the SUTRA output data.

3.2 Set-Up Files

Prior to plotting the output from a simulation for the first time, information such as plot dimensions, scaling, contour intervals, and other plot parameters is needed. The file that contains the information is referred to as a 'set-up' file in the program and in this documentation. The set-up file is created interactively at the terminal and may be saved in a disk file for later use. A set-up file is required for each type of plot (contour, vector or meshplot), and for each type of contour plot (pressure, temperature, concentration, or saturation). However, once a set-up file is created for a particular mesh, the set-up may be used for all plots of subsequent simulations with the same mesh.

3.3 User Inputs

The terminal inputs are standard ASCII, so that virtually any type of terminal may be used with SUTRA-PLOT. In the explanations of SUTRA-PLOT options in the following sections, the SUTRA-PLOT prompts printed at the user terminal are printed in italics. All user responses require a carriage return (C/R) at the end. Some of the multiple entries of the plotting options which indicate free format may be entered on a single line with spaces between entries (e.g., 10(space)25C/R), single line with a comma between entries (e.g., 10,25C/R), or on separate lines (e.g., 10C/R25C/R).

Menu options are selected by number, or by a single letter (upper or lower case) as indicated in the menu. In sub-menus, entering an 'X' will exit the menu and return the the main menu. Entering an 'X' in the main menu will exit the program. If, while selecting any menu option, the menu inadvertently scrolls off the screen, entering a 'M' will re-display the menu. SUTRA-PLOT queries requiring a yes or no response need only a 'Y' or 'N'.

3.4 SUTRA-PLOT Output

The graphic output of SUTRA-PLOT generally will be directed to a physical device such as a CRT or pen plotter. However, the graphic output may alternately be saved in a device independent metafile, rather than plotted. SUTRA-PLOT, however, does not plot from metafiles. Plots stored in metafiles may be stored on tape, transferred to other installations for plotting, and so forth. A post-processor program generally is necessary to produce the plots stored in metafiles. See the DISSPLA User's Manual (Integrated Software Systems Corporation, 1984) for specific details for using metafiles.

Each time SUTRA-PLOT is run, error messages and diagnostics from DISSPLA are written to an output file 'PLOT.OUT'. If unusual or unexpected plotting results are obtained, check the contents of PLOT.OUT after exiting SUTRA-PLOT.

3.5 Main Menu

After data from the SUTRA input file are successfully read, the SUTRA-PLOT main menu will be displayed as illustrated below.

```
================================================
          S U T R A - P L O T
     I N T E R A C T I V E  G R A P H I C S
================================================
------------------------------------------------
**********      M A I N  M E N U      **********
------------------------------------------------
          Select graphics option:
        1) Create a new plot set-up
        2) Read-in existing set-up file
        3) Modify current set-up
        4) Save new or modified set-up
        5) Re-start with new INPUT DATA
        6) Read new SUTRA OUTPUT
        7) PLOT
          or (X) Exit program
================================================
```

All subsequent operations are selected from this menu. The main menu options are briefly described below.

1) Create a new plot set-up

The program will prompt for all the necessary information to set-up the scaling, plotting dimensions, and appropriate parameters for each type of plot. Plot types and associated plotting options are explained separately in later sections.

2) Read in existing set-up file

A set-up file created from a previous plot may be used only if the finite-element mesh has not changed. A separate set-up is required for each type of plot. A basic set-up file can be created for each finite-element mesh and later modified for different types of plots.

3) Modify current set-up

A simple edit routine allows any of the plotting parameters of the set-up currently in memory to be changed without getting out of the program. Set-ups may be changed and re-plotted as many times as needed.

4) Save new or modified set-up

Any newly created or modified set-up may be saved to a disk file either before or after plotting. The program will prompt for a filename. If the filename already exists, the program will display an error message and prompt for another name. It is not possible to delete set-up files from SUTRA-PLOT.

5) Re-start with new INPUT DATA

This option re-starts SUTRA-PLOT as if the program had been started from PRIMOS level. The program will prompt for a new INPUT DATA file, and new SUTRA output and set-up files will also be needed.

6) Read new SUTRA OUTPUT

Results from several simulations may be plotted by reading in different SUTRA output files one at a time. The INPUT DATA file is not re-read and the set-up file need not be re-read.

7) PLOT

Simulation results using the most recently read INPUT DATA file, and SUTRA output file, with current set-up file are plotted. SUTRA-PLOT will prompt for an output device as programmed in subroutine OUTDEV.

(X) EXIT program

Leaving the program using this option assures that all files are closed. If the program ends because of a fortran error or the 'break' key is inadvertently pressed, it is necessary to check that all files are closed before re-running the program.

4. PLOTTING OPTIONS

The current version of SUTRA-PLOT (V1086S) supports three type of plots: contour, velocity vector, and finite-element mesh plots. Contour plots of pressure, concentration, temperature, or saturation can be generated. The plotting options are described in the following sections. The plot dimensions apply to all plots and are described in section 4.1. Specific options for each type of plot are described in sections 4.3 (contour), 4.4 (vector), and 4.5 (mesh). A description and explanation for the 'gridding' required for contour plotting is in section 4.2.

Options are entered interactively by selecting 'Create a new plot set-up' from the main menu. The user is first prompted to select a type of plot.

*** C R E A T E N E W S E T - U P ***

Select type of plot:

1) Contour

2) Velocity vector

3) Meshplot

Enter 1,2, or 3

After the type of plot is selected, then the plotting page dimensions and plot dimensions must be specified.

4.1 Plot Dimensions and Axis Options

The plot dimensions and axis information are common to all three types of plots. Plotting dimensions which have already been created for any type of plot may be used.

PAGE and AXIS set-up

1) Read-in page set-up from existing file

2) Use information in current set-up

3) Create new page set-up

Enter 1,2, or 3

Page and axis dimensions from an existing set-up file can be used if the current set-up is being created for output generated from the same finite-element mesh. If option 1 or 2 is selected plot dimension and axis options will be skipped.

Enter label for x-axis

(C/R = no label)

A label of up to 59 characters may be printed below the x-axis. C/R cancels the x-axis label; however, a blank line is printed.

Enter label for y-axis

(C/R = no label)

A label of up to 59 characters may be printed vertically along the y-axis. C/R cancels the y-axis label; however, a blank line is printed.

Enter plotting page dimensions in inches (X,Y)

Free format. The page size defines the area within which all plotting has to appear including axes and labels. Any part of the plot beyond the page border is clipped. On pen plotters the page size usually defines the maximum physical dimensions of the plotter. On CRT devices, such as the TAB graphics terminal, dimensions specified larger than the screen are automatically reduced by DISSPLA to fit within the screen. However, proportions of the page dimensions are retained.

Plotted axis lengths will be automatically
set proportional to the coordinate range
in the input data list
X-coordinate range = xxxx.xx (model units)
X-axis will be set = xx.xx inches
Y-coordinate range = xxxx.xx (model units)
Y-axis will be set = xx.xx inches
Do want to change these settings? (Y/N?)

The axis lengths define the rectangular area within which all data curves (contour lines, vectors, etc.) will be drawn. SUTRA-PLOT uses a grace margin of 1.0 inch. Data curves drawn more than 1.0 inch beyond this plotting area are clipped. The default axis lengths are specified 2 inches less than the page dimensions to allow space for axis numbering and labeling. These axis lengths may be changed to allow for unequal scales or vertical exaggeration. If 'Y' is selected, the following option is displayed.

Enter axis lengths in inches (X,Y)

Free format. This option resets the X-axis and Y-axis values calculated above. The axis lengths should be specified at least 2 inches less than the page dimensions.

Minimum X-coordinate = xxxx.xx
Maximum X-coordinate = xxxx.xx
Enter increment for X-axis ticks in model units

The minimum and maximum coordinates displayed are calculated from the SUTRA input data list in scaled model units. Tick marks and axis numbering will be printed below the x-axis at the specified increment.

Minimum Y-coordinate = xxxx.xx
Maximum Y-coordinate = xxxx.xx
Enter increment for Y-axis ticks in model units

The minimum and maximum coordinates displayed are calculated from the SUTRA input data list in scaled model units. Tick marks and axis numbering will be printed along the y-axis at the specified increment.

4.2 SUTRA-PLOT Gridding

The contouring subroutines in DISSPLA, like most other contouring software, require that the user provide a regular set of data points on an evenly spaced grid. Such a grid must have equally spaced vertical lines (columns) and equally-spaced horizontal lines (rows), with both sets of lines perpendicular to each other forming equal rectangles. If the data points to be contoured are irregularly spaced, then it is necessary to construct a regular matrix of values that would define the same surface as the irregularly spaced values. This is commonly known as 'gridding the data'.

Some confusion may arise in the discussions when reference is made to both grids and meshes. In this report 'grid' and 'grid point' (grid line intersections), refer to the regular matrix of data directly employed by SUTRA-PLOT and passed to the DISSPLA contouring subroutines. 'Mesh' and 'node' will always refer to the original finite-element mesh used in the SUTRA simulation. Gridding, as used in SUTRA-PLOT, is the estimation or exact calculation of values at a regular array of grid points from regularly or irregularly spaced node values obtained from a SUTRA simulation. The three options for gridding provided by SUTRA-PLOT are discussed below.

DISSPLA gridding option.--There are many techniques for gridding data, and most are interpolations in the form of averages, weighted averages, trend-surface analysis, or kriging. DISSPLA uses an inverse-distance weighted averaging technique. This technique searches a specified area around a grid point, and averages only node values found within this area. DISSPLA gridding is relatively fast and works well with randomly spaced data. A problem arises when a finely spaced grid is used with a finite-element mesh having both finely spaced and widely spaced nodal data (see Thermal transport example, section 5.2). In areas of the mesh where the nodes are much farther apart than the grid points, the DISSPLA interpolation routine will not locate any data points. The grid point, in this case, is assigned a value of zero and unexpected contours will be drawn. The problem can be fixed by using a

very coarse grid; however, there is a trade-off and detail will then be lost in the fine part of the mesh.

Finite-element gridding option.--An alternative gridding routine is provided, which calculates exact values at grid points regardless of the finite-element mesh spacing. This routine is referred to as the 'Finite-element grid program' in SUTRA-PLOT, and is implemented in subroutine GRIDR. GRIDR is an interpolation routine which uses basis functions equivalent to those employed in SUTRA finite-element methodology. In SUTRA's finite-element simulations, a surface is used to represent the spatial distribution of parameters rather than only single parameter values at nodes (see fig. 6.1). The interpolation routine in GRIDR calculates exact values on this surface defined by the set of nodal parameters.

Because the interpolated surface calculated in GRIDR is exact, there is no restriction to the size of grid that can be used, large or small. Fine grids will produce smoother contour lines and give the best representation of values between nodes. Plotting with very fine grids, however, may be slow because of the large computational effort required to create the grid.

Details of the numerical algorithm for the interpolation routine used in SUTRA-PLOT can be found in the description of subroutine GRIDR (section 6). For a more complete description of the numerical methods, refer to the SUTRA documentation (Voss, 1984; sections 3.2, 'Nodewise discretization', and 4.1, 'Basis and Weighting Functions').

No gridding option.-- A finite-element mesh which is regular and rectangular, and numbered consecutively along rows or columns, meets the DISSPLA data requirements for a grid and may be directly contoured. For regular finite-element meshes, this method is recommended as it is fast, and produces an excellent contour plot, particularly if the mesh is finely spaced. If a regular mesh is coarse, gridding with fine spacing can be used to get smoother contour lines between nodes.

However, many meshes take advantage of the flexible geometry of finite-elements, and have irregularly spaced nodes. The output data from such meshes must be gridded with one of the two methods for gridding available in SUTRA-PLOT before contouring.

4.3 Contouring Options

If a contour plot is selected from the set-up menu, the type of contour plot must first be selected.

Select type of contour plot:
1) Concentration
2) Temperature
3) Pressure
4) Saturation
Enter 1,2,3, or 4

Select the appropriate type of plot for the type of simulation. SUTRA- PLOT assumes the output file contains the correct type of data for the plot. If the set-up file contour plot type and output do not match, an 'END OF FILE' error will result. For all contour plots, a gridding method must be selected.

Select method for gridding data:
1) DISSPLA grid routine
2) Finite-element grid program
3) No gridding - (regular, rectangular finite-element meshes only)
Enter 1,2, or 3

See explanation for gridding in section 4.2. For regular finite-element meshes, the 'no gridding' option will produce the fastest plot. If the mesh is irregular or more detail is required in the contour lines, the finite-element gridding is recommended. A significant amount of computational effort is required to create the finite-element grid and contours generated with a fine grid may take several minutes to draw. However, part of the gridding is saved in the set-up file and subsequent plotting time is reduced by about one-fourth. If option 1 or 2 is selected, the grid matrix must be specified.

Enter dimensions of gridding matrix (X,Y)
(x=number of columns; y=number of rows)

Free format. The number of grid points in the X-direction determines the number of columns, and the number of grid points in the Y-direction determines of the number of rows in the gridding matrix. If the 'No gridding' option (3) is selected, a sub-menu and warning will be displayed.

```
**********************   CAUTION   **********************
          <<NO GRIDDING>> OPTION SELECTED
**************************************************
   Data may be contoured without gridding ONLY if
  the finite-element mesh is RECTANGULAR and REGULAR
   The number of rows and columns for the grid must
   be set equal to the number of rows and columns
              in the finite-element mesh
        ** Mesh numbering flag MUST be set **
==================================================
  Select one:
    Change:
  1) X-grid-dimension (columns):    IXDIM= xx
  2) Y-grid-dimension (rows):       IYDIM= xx
  3) Mesh numbering flag:    NUMDIR= 0
     0=mesh numbered along rows (X-direction)
     1=mesh numbered along columns (Y-direction)
  4)Use    <<No gridding>> option
  5)ABORT <<No gridding>> option
```

See explanation for gridding in section 4.2. Check that the number of rows (IYDIM) and the number of columns (IXDIM) in the grid are set exactly equal to the number of rows and columns in the original finite-element mesh. Check the direction that the original finite-element mesh is numbered and set the numbering flag (NUMDIR). Then finally select (4) to invoke the 'No gridding' option. The mesh dimensions and numbering should be checked and noted prior to running SUTRA-PLOT.

Do you want to re-scale the data prior to contouring?
(Y/N?)

The simulation data may be re-scaled to adjust the range of very large or very small numbers. When plotting the results of a new simulation for the first time, the safest option is use the raw simulation data (not re-scaled) and let DISSPLA select the contour interval. Once the range and magnitude of the data are established, the data can be re-scaled with the edit routine. Enter 'Y' if you want to re-scale the simulation data. If re-scaling is selected, two scaling factors must be specified.

Enter scaling factors (UBASE,UMULT)
[Plotted data = (true data/UBASE) UMULT]*

Free format. The scaling factors change the data as shown above. For example, in the Rocky Mountain Arsenal sample plot (section 5.1), very small concentration values (on the order 5 X 10^{-4}) were multiplied by 10^{6} so that plotted values (fig. 5.3) would fall between 0 and 1000. In this case, UBASE = 1.0, and UMULT = 10^{6}.

Do you want DISSPLA to select contour intervals (Y/N?)

When plotting the results of a new simulation for the first time, the safest option is to let DISSPLA select the contour interval. Once the range and magnitude of the data are established, the interval can be changed with the edit routine. To select a specific contour interval, enter 'N'.

Enter a value for contour interval

If UBASE and UMULT are used to re-scale the range and magnitude of the contour interval, the contour interval entered here must be compatible with the re-scaled units. See Rocky Mountain Arsenal plotting example (section 5.1). All of the contour lines are drawn with the same type of line. The default line characteristics may be changed as described below.

Default line characteristics are:

- *solid lines*
- *labels*
- *thickness 0.01 inch*

Change defaults (Y/N?)

If 'Y' is selected, the following options are displayed.

Line types:

1) Dot

2) Dash

3) Chain dotted

4) Chain dashed

5) Solid

Enter 1,2,3,4, or 5

Contour line types are self-explanatory.

Labeling options:

1) Label the lines

2) No labels

Enter 1 or 2

The 'No labels' option is useful if the contour are to be re-labeled for publication.

Enter line thickness in INTEGER multiples
of 0.01 inch (e.g., 5 = 0.05 inch)

The number entered actually determines the number of times each line is drawn. On pen plotters, the line thickness drawn will depend on the size of the pen tip. DISSPLA will draw each line once for each 0.01 inch of 'thickness', offset by 0.01 inch.

4.4 Velocity Vector Options

If a velocity vector plot is selected from the set-up menu, the following options are displayed:

Enter plotted length for the largest vector in inches
All vectors are scaled as a fraction of
the plotted length of the largest vector

The maximum vector magnitude is calculated from the SUTRA output data. All other vectors are plotted as a fraction of the maximum. On pen plotters, vectors will always be drawn in inches. If large page dimensions have been specified, DISSPLA may reduce the plot to fit a CRT screen, and the plotted vector length may be smaller than specified. Arrowhead sizes, selected below are not affected by LENGTH. Two types of scaling are available, described below.

Select type of vector length scaling:
1) Linear fraction of largest vector
2) Logarithmic fraction of largest vector

Linear scaling will plot vector lengths as a linear fraction of the largest vector. The length of the largest vector is set by the LENGTH setting above. Logarithmic scaling will plot vector lengths as a fraction of the largest vector using a logarithmic function, such that for each reduction in magnitude by $1/10^n$, the plotted length is reduced by $1/(n+1)$. This logarithmic relationship is shown graphically in figure 6.3. For details of the logarithmic scaling refer to the description of subroutine VECPLT.

Re-scale vector DIRECTION to conform to a
distorted plot page? (e.g., a cross-section
with vertical exaggeration)
(Y/N?)

The angles of the vectors can be transformed to indicate true direction on distorted page when the x- and y-axis scales are not equal. Angle re-scaling

is highly desirable for cross-sections with very large vertical exaggeration (see fig. 6.4). For more explanation of this type of angle scaling, refer to the description of subroutine VECPLT.

Default vector type is:
-Stick arrowhead, ->
-Plotted arrowhead size = 0.15 inch
Change defaults? (Y/N?)

The default vector arrow characteristics may be changed as described below. If 'Y' is selected, the two following options are displayed:

Arrowhead types:
1) Solid
2) Empty
3) Stick
Select 1,2, or 3

Solid is a filled-in triangle (slowest plotting). Empty is an open triangle. Stick is a simple 'V' (fastest plotting).

Arrowhead size (inches):
1) 0.075
2) 0.15
3) 0.225
4) 0.3
5) 0.375
6) 0.45
Select one

On pen plotters, this option always determines the actual plotted length of the arrowhead. The size of the arrowhead when plotted is independent of the vector length. If large page dimensions have been specified, DISSPLA may reduce the plot to fit a CRT screen, and the plotted arrowhead size may be smaller than specified.

Vector thinning options:
1) No thinning-plot all vectors
2) Plot every Nth vector
3) Skip small vectors
Select 1,2, or 3

When plotting vectors in very dense meshes, particularly on a CRT, it is useful to eliminate some of the vectors for clarity. The two thinning options available are described below.

For option 2:

Enter skip interval for vector thinning:
(e.g., 3= plot every third vector)

The program uses the selected interval (ISKIP) as the step size in the loop that plots the vectors. The vector in element one is plotted, then every ISKIPth vector is plotted. Thus, the larger the interval, the smaller the number of vectors plotted.

For option 3:

Enter a fractional length of largest vector:
(e.g., 0.01= Will NOT PLOT vectors less than
one-hundredth of the largest

This type of thinning can be used with both linear and logarithmic length scaling.

4.5 Mesh Plot Options

If a mesh plot is selected from the set-up menu, the following set of options is displayed.

Select one:

1) Plot ALL sides of ALL elements

2) Plot WITHOUT duplicating sides

3) Plot PERIMETER of mesh only

The mesh plotting program uses the node coordinates and nodal incidence list read from the SUTRA INPUT data list to draw the finite-element mesh. Because elements share sides, drawing every side of every element results in most sides being drawn twice. Plotting the mesh in this way, however, is a very effective way of checking a newly created data list, particularly if the mesh is complex and has been constructed manually. Erratic coordinates or incorrect nodal incidences are evident when watching the mesh being plotted.

On fast pen plotters, some types of pens may tend to clog and the pen speed may need to be reduced. Option 2 for plotting without duplicating sides runs slowly, especially for large meshes. However, option 2 produces a cleaner plot more suitable for publication. Option 3 for plotting the perimeter of the mesh uses a similar logic to (2) and also runs slowly. However, after the first plot of a perimeter, a list of the perimeter nodes is saved in the set-up file and subsequent plots run very fast.

4.6 Editing Set-Up Files

A simple editor is provided in SUTRA-PLOT to allow interactive modification of any of the plotting parameters while the program is running. The edit routine is invoked by selecting option '3' ('Modifying current set-up') from the main menu. The main 'EDIT SET-UPS' menu is illustrated below.

The plot layout parameters are modified with this menu. In addition, option '1' selects sub-menus for modifying parameters unique to the contour, vectorplot, or meshplot. In each menu, the current parameter is displayed next to the option. An example of the edit main menu showing the options selected for the Rocky Mountain Arsenal pressure plot (see section 5.1) is shown below.

```
================================================

                E D I T    S E T U P S

================================================

     Current PLOT LAYOUT parameters
   Enter number of plot layout parameter to change
            (enter <X> to EXIT edit)
 ------------------------------------------------
 1) LIST CONTOUR PLOT PARAMETERS
    PAGEX=    8.00      PAGEY=    8.00
 2) Change page dimensions and re-scale axis lengths
 3) Change page dimensions ONLY
 4) X-axis length, in inches: XAXIS=    4.00
 5) Y-axis length, in inches: YAXIS=    5.00
 6) X-interval for ticks, model units: XINT=   4000.0000
 7) Y-interval for ticks, model units: YINT=   5000.0000
 8) Minimum X-coordinate: XMIN=        0.00000
 9) Minimum Y-coordinate: YMIN=        0.00000
10) Maximum X-coordinate: XMAX=    16000.00000
11) Maximum Y-coordinate: YMAX=    20000.00000
12) X-axis label: LXNAME= DISTANCE, IN THOUSANDS OF FEET
13) Y-axis label: LYNAME= DISTANCE, IN THOUSANDS OF FEET
  ------------------------------------------------
```

Parameters are changed by first selecting the number of the option, then entering the new value when prompted. After completing changes to the set-up file, entering an 'X' will exit the edit routine and return to the main menu. Set-up files may be modified and re-plotted as needed. Any of the set-up files may be saved using option '4' from the main menu. Each saved file will require a new name. SUTRA-PLOT will not overwrite an existing file.

5. EXAMPLES OF PLOTTING APPLICATIONS

This section contains six sample plots produced by SUTRA-PLOT. Two simulation examples from the SUTRA documentation are used. Each example is accompanied by a list of the SUTRA-PLOT options used and a short discussion of any special features of the plot. For details of the physical set-up and parameters of the simulations, refer to the SUTRA documentation (Voss, 1984). The sample plots were all produced on a Houston Instruments DMP-52 pen plotter. Figures 5.2-5.7 are exact reproductions of the original plots.

5.1 Areal Constant-Density Flow and Solute Transport (Rocky Mountain Arsenal Simulation)

This example shows results of a ground-water flow and solute transport model of an alluvial aquifer. The regional flow (north-west to south-east) is distorted by two impermeable bedrock outcrops (fig. 5.1). Three wells pump from the aquifer (Q_{out}), and a solute enters the system at Q_{in}.

The page dimensions and axis options for figures 5.2, 5.3, and 5.4 were set-up as follows:

```
Plotting page dimensions (X,Y):  8 by 8 (inches)
Axis lengths (X,Y):  4 by 5 (inches)
X-axis tick mark increment:  4000.0
Y-axis tick mark increment:  5000.0
X-axis label: DISTANCE, IN THOUSANDS OF FEET
Y-axis label: DISTANCE, IN THOUSANDS OF FEET
```

Additional plotting options are noted on each individual plot.

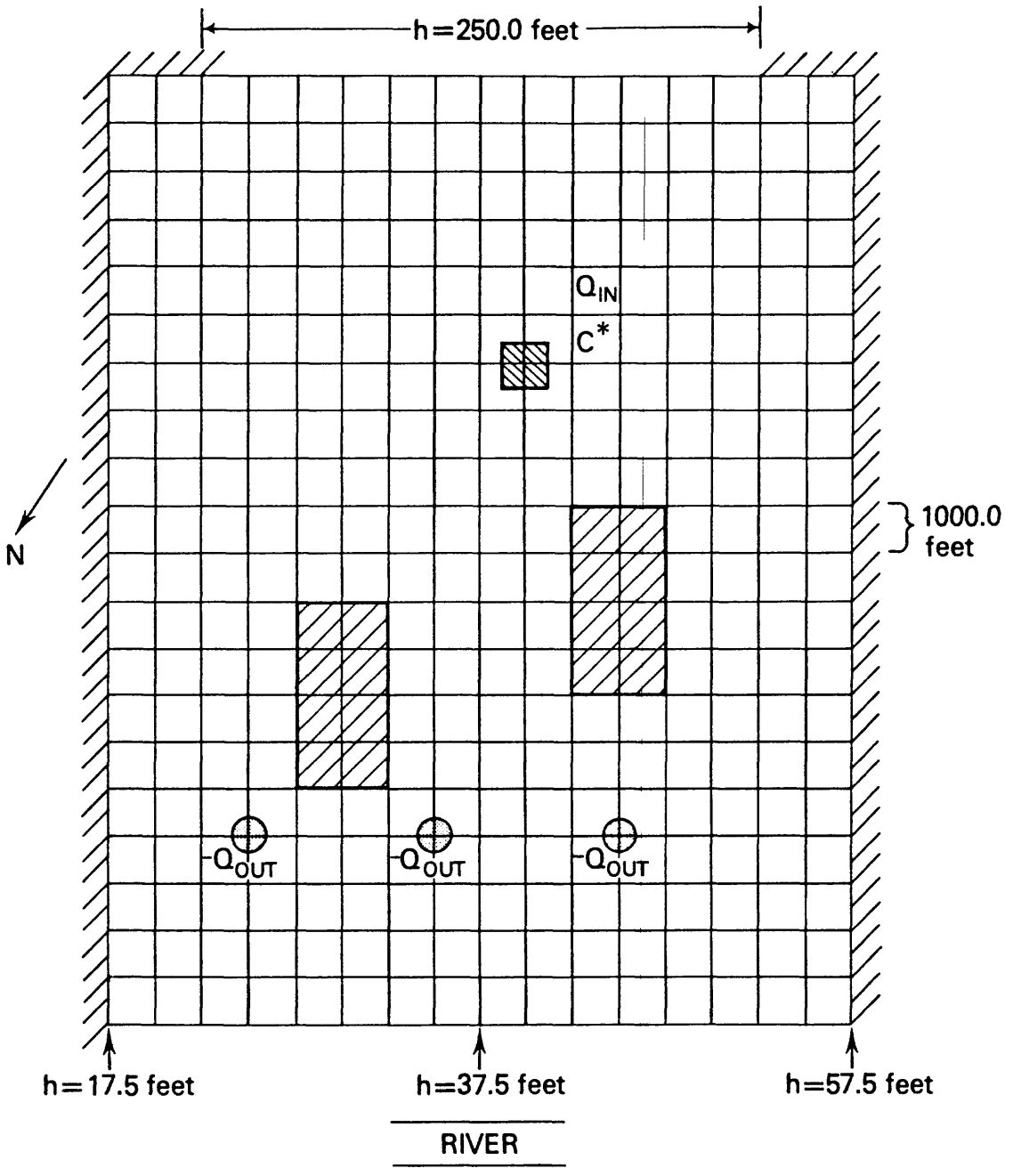
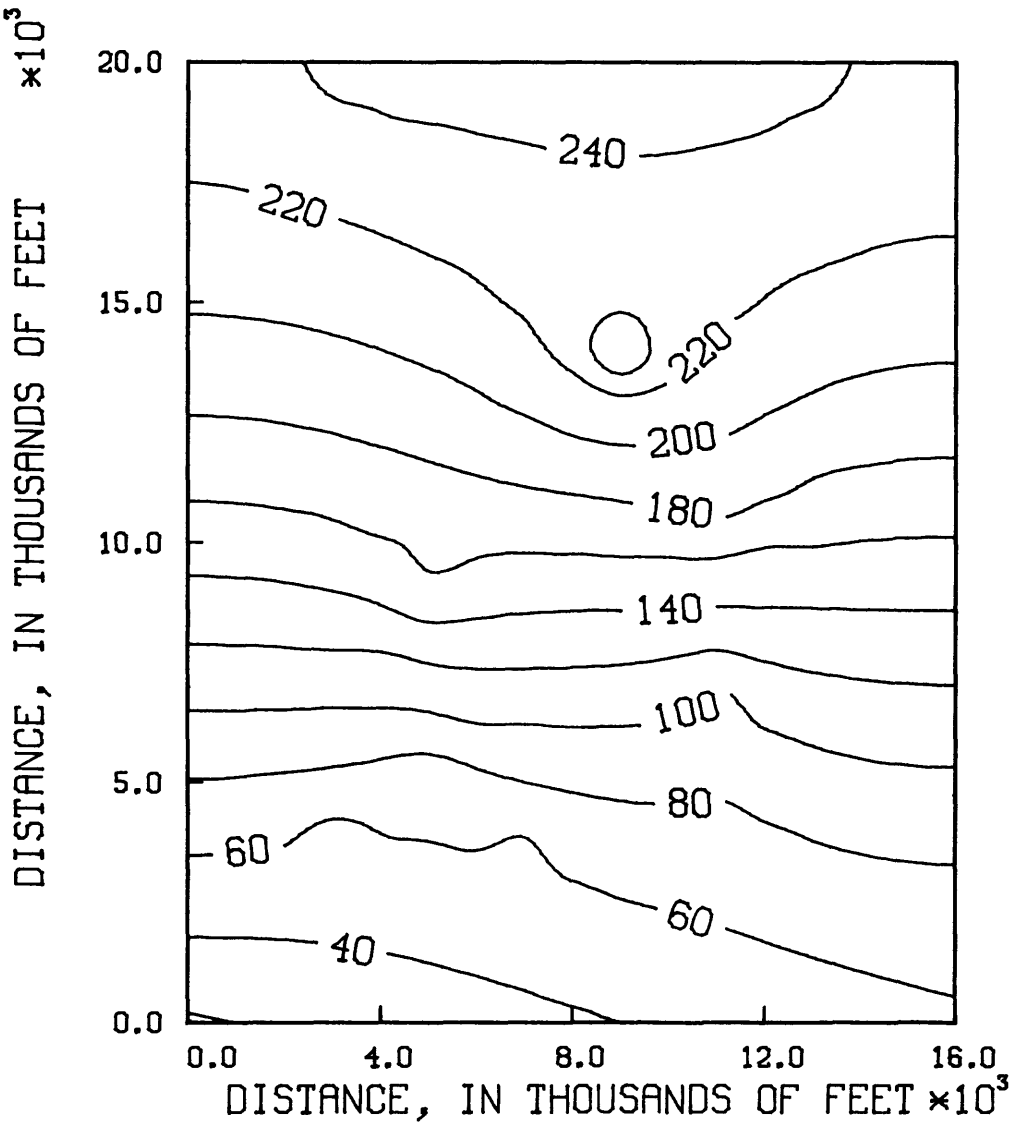


Figure 5.1. Idealized representation for example at Rocky Mountain Arsenal and finite-element mesh (from Voss, 1984).

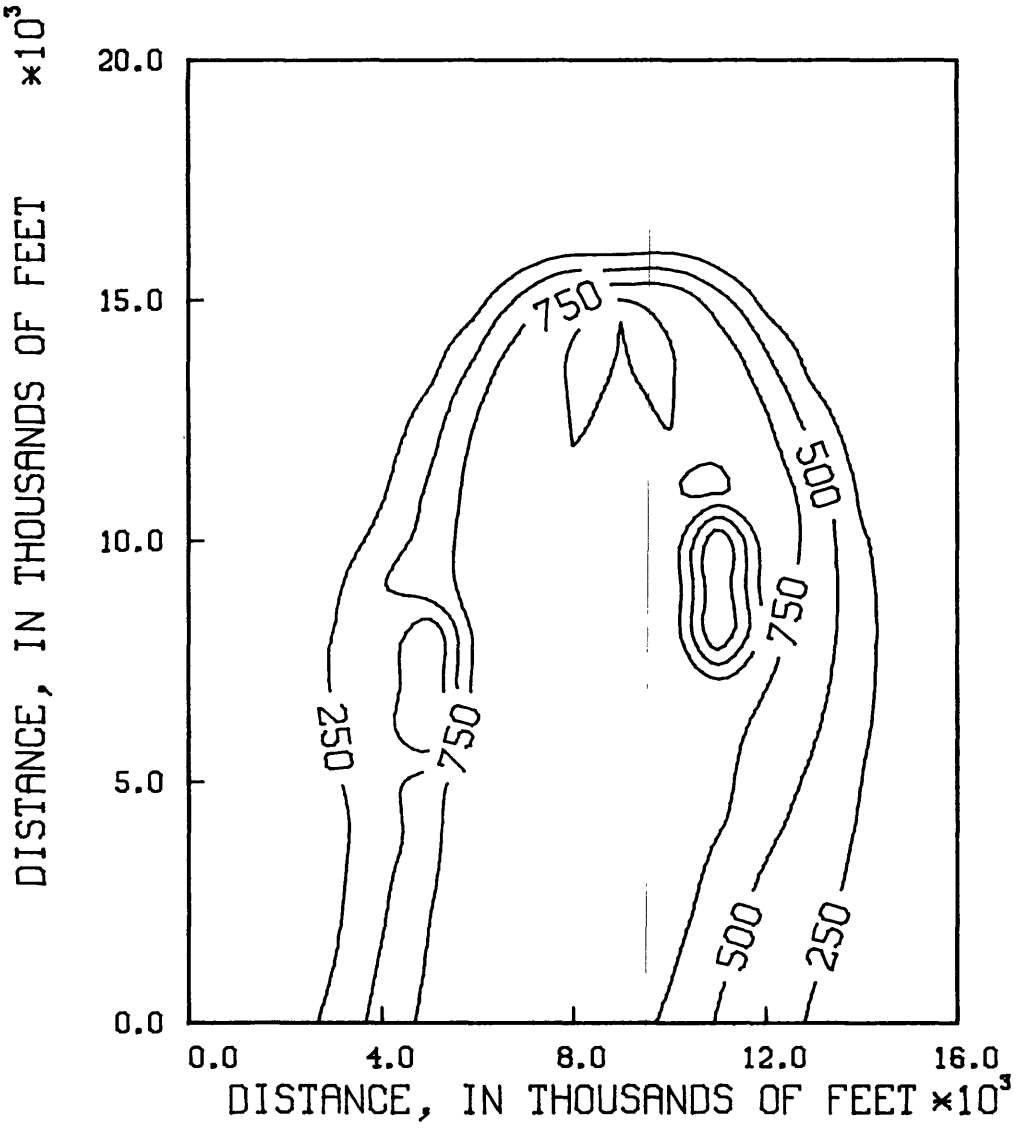


SUTRA-PLOT options for CONTOUR PLOT

Type of contour plot: PRESSURE
Gridding method: NO GRIDDING
Gridding dimensions (columns,rows): 17 by 21
Data scaling: NO SCALING
Contour interval selection: DISSPLA SELECTED
Contour line characteristics: DISSPLA DEFAULTS

Comments: The square mesh used in the simulation does not require gridding prior to contouring. The gridding dimensions passed to DISSPLA had to be set to the exact number of columns (17) and rows (21) in the finite-element mesh. The contours represent feet of head which was converted from pressure in the simulation.

Figure 5.2. SUTRA-PLOT generated head contours; Rocky Mountain Arsenal simulation.

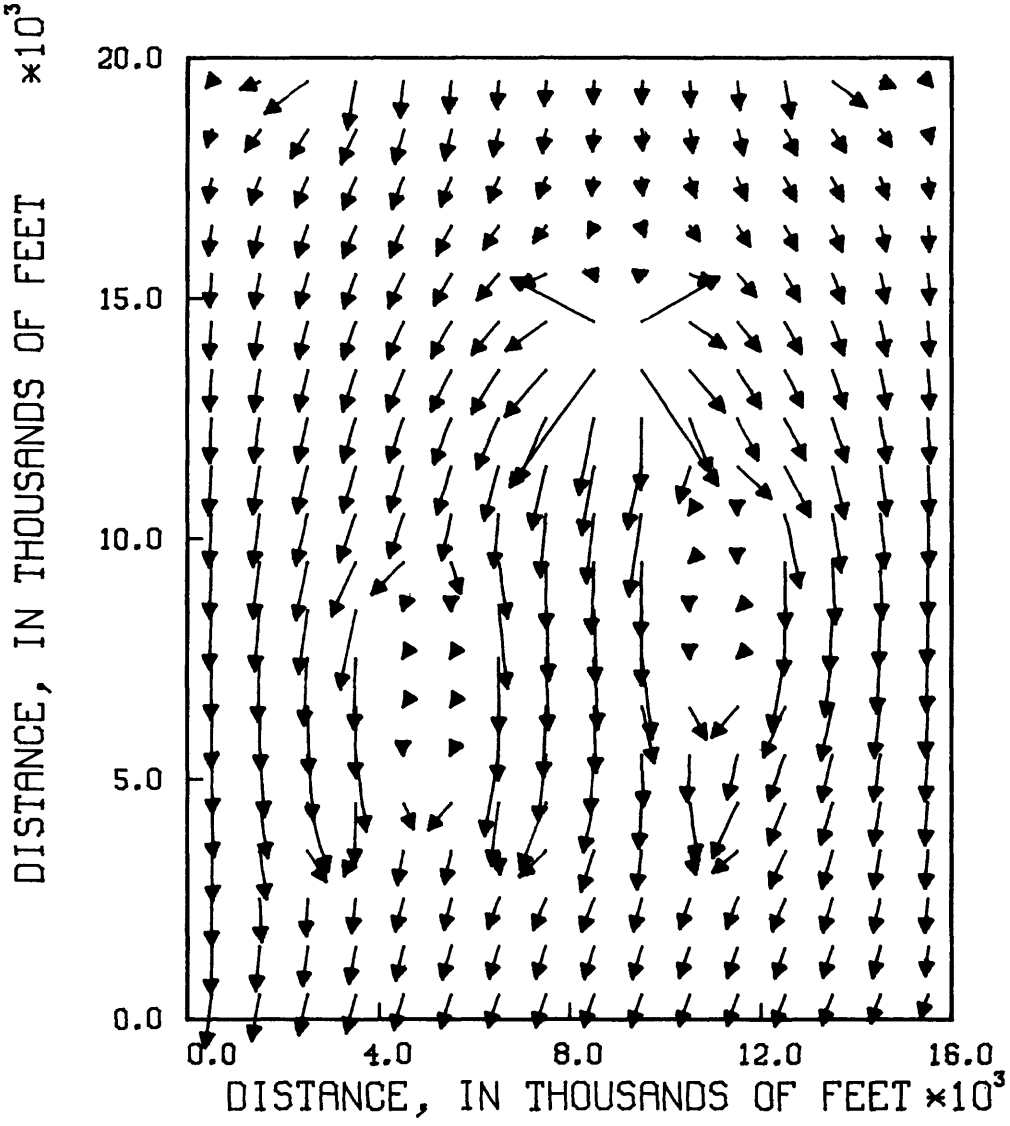


SUTRA-PLOT options for CONTOUR PLOT

Type of contour plot: CONCENTRATION
Gridding method: NO GRIDDING
Gridding dimensions (columns,rows): 17 by 21
Data scaling: USER SELECTED;
UBASE = 1.0
UMULT = 1000000.0
Contour interval selection: USER SELECTED = 250.0
Contour line characteristics: DISSPLA DEFAULTS

Comments: The concentration results produced by SUTRA were on the order of 10 kg/kg. Multiplying all values by 10^6, re-scales the data to mg/L (approximate). Contours in the area of the outcrops have been smeared across the outcrop boundary by the contouring process and would be ignored when evaluating the model results.

Figure 5.3. SUTRA-PLOT generated steady-state solute plume; Rocky Mountain Arsenal simulation.



SUTRA-PLOT options for VELOCITY VECTOR PLOT

Maximum plotted vector length: 0.75 (inch)
Vector length scaling: LINEAR
Vector angle scaling: NO SCALING
Vector arrow type: USER SELECTED;
    Arrowhead type: SOLID
    Arrowhead size: 0.075 (inch)
Vector thinning option: NO THINNING

Figure 5.4. SUTRA-PLOT generated ground-water velocity vectors; Rocky Mountain Arsenal simulation.

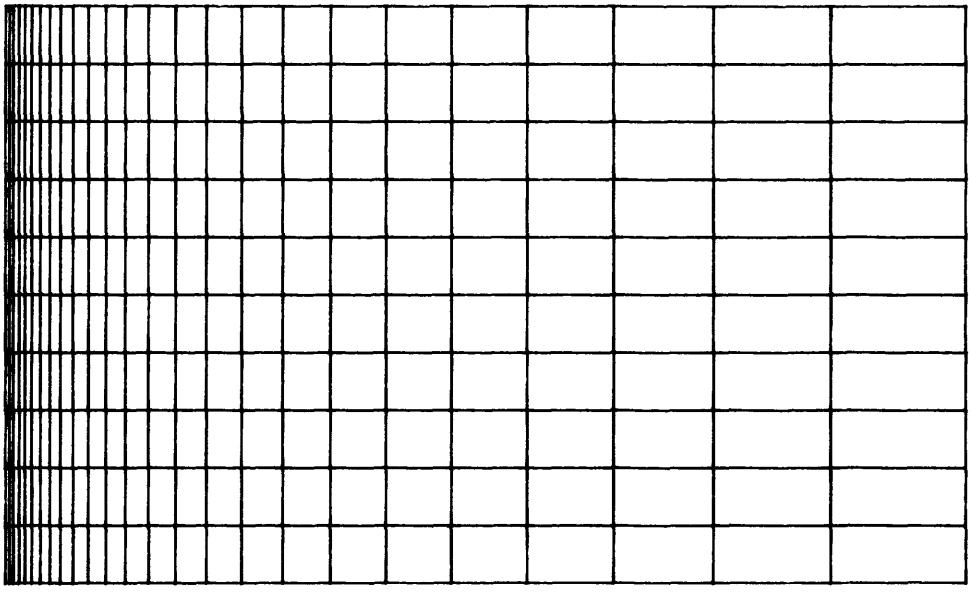
5.2 Density-Dependent Radial Flow and Energy Transport (Aquifer Thermal Energy Storage Simulation)

This example shows results of flow and energy transport in a vertical section of an aquifer. A fluid source is located at the left vertical boundary which represents the center axis of a circular system with radial symmetry (fig. 5.5). In the simulation, hot water (60° C) is injected into the aquifer at the left boundary.

The page dimensions and axis options for figures 5.5, 5.6, and 5.7 were set-up as follows:

Plotting page dimensions (X,Y): 7 by 7 (inches)
Axis lengths (X,Y): 5 by 3 (inches)
X-axis tick mark increment: 25.0
Y-axis tick mark increment: 5.0
X-axis label: RADIAL DISTANCE, IN METERS
Y-axis label: ELEVATION, IN METERS

Additional plotting options are noted on each individual plot.

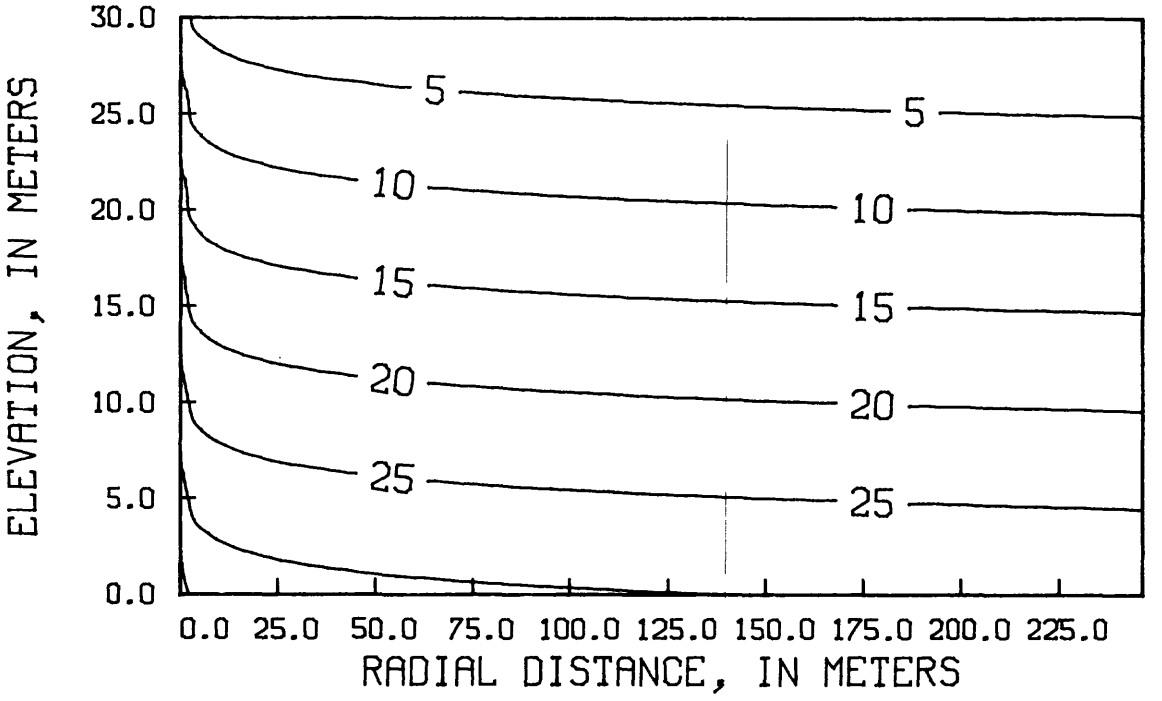


SUTRA-PLOT options for FINITE-ELEMENT MESH PLOT

Mesh plotting mode: PLOT ALL SIDES OF ALL ELEMENTS

Comments: Axis labels identical to those of figures 5.6 and 5.7 were specified in this plot; however the neither the labels nor the axis grids are used in the mesh plotting subroutine.

Figure 5.5. SUTRA-PLOT generated finite-element mesh; Radial energy transport simulation.

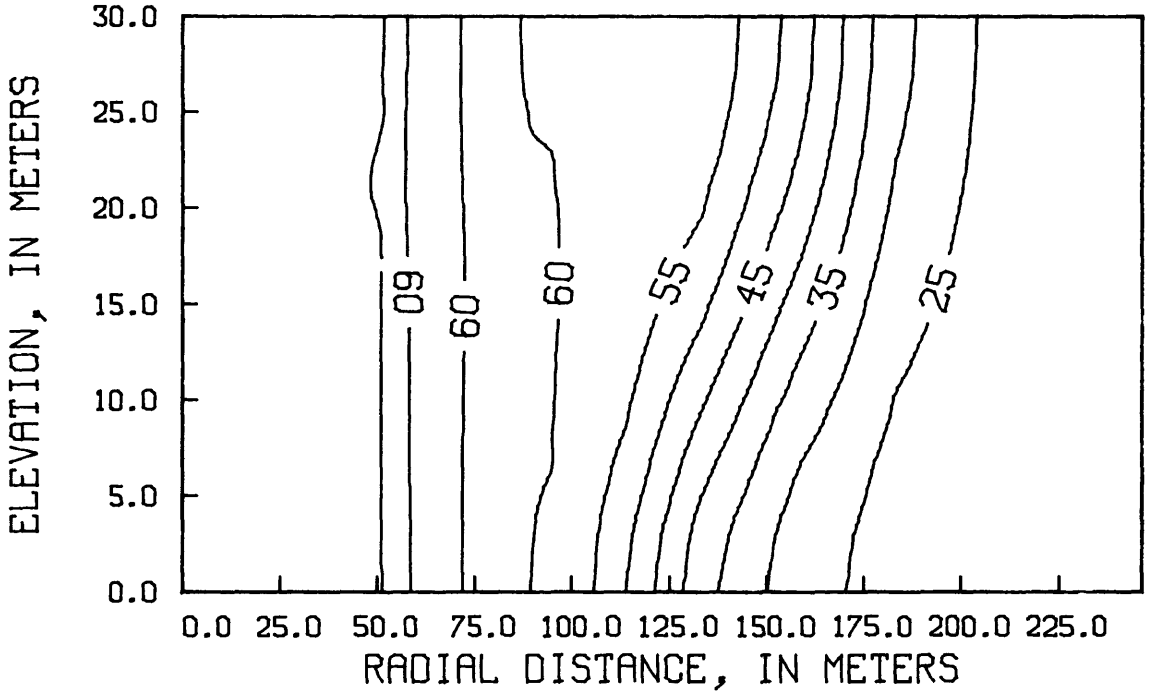


SUTRA-PLOT options for CONTOUR PLOT

Type of contour plot: PRESSURE
Gridding method: FINITE-ELEMENT
Gridding dimensions (columns,rows): 80 by 20
Data scaling: USER SELECTED;
UBASE = 10000.0
UMULT = 1.0
Contour interval selection: USER SELECTED = 5.0
Contour line characteristics: DISSPLA DEFAULTS

Comments: Finely-spaced horizontal gridding was used so that detail would not be lost at the left side of the mesh. Finite-element gridding is necessary with this grid because of the large variation in the horizontal dimension of the elements. Pressure data (on the order of 10^5 Pa) was scaled by dividing all values by 10^4 so that less digits would be printed in the contour line labels improving the readability of the plot.

Figure 5.6. SUTRA-PLOT generated pressure contours; Radial energy transport simulation (finite-element gridding, 80 X 20 grid).



SUTRA-PLOT options for CONTOUR PLOT

Type of contour plot: TEMPERATURE
Gridding method: FINITE-ELEMENT
Gridding dimensions (columns,rows): 40 by 20
Data scaling: NO SCALING
Contour interval selection: USER SELECTED = 5.0
Contour line characteristics: DEFAULT

Comments: Several extraneous contour lines (for 60° C) are plotted as a result of very small oscillations in the simulation results. These oscillations do not affect the validity of the solution and the lines can be ignored when evaluating model results.

Figure 5.7. SUTRA-PLOT generated temperature contour plot after 90 days of hot water injection; Radial energy transport simulation (finite-element gridding, 40 X 20 grid).

6. PROGRAM STRUCTURE AND SUBROUTINE DESCRIPTIONS

SUTRA-PLOT is structured in a modular style that allows code readability and ease in tracing logic. It can be easily modified for individual or specialized uses. Subroutines are independent from each other and from the main program and are reasonably self-contained. Required user changes to the program are limited to: 1) dimensioning five large storage arrays in the main program, and 2) modifying part of or replacing subroutine OUTDEV which is used to nominate graphic output devices.

SUTRA-PLOT is written in Fortran-77 and, because of the extensive use of character data and functions, would require extensive re-programming to be compatible with Fortran-66. The program code was compiled and tested using Revision 19.4 of the PRIME FORTRAN 77 compiler. Additionally, the program requires Version 9.0 or higher of the DISSPLA graphics library. The code needs to be compiled and linked to a standard Fortran library and the DISSPLA graphics library. The program code requires "double precision" real variables (64-bit word with 47-bit mantissa) with 15 significant figures and 32-bit word integer variables.

The logic flow of SUTRA-PLOT is straightforward. The main program sets up dimensions for all arrays and calls the main control routine, SUTRAP, which controls program flow and plotting options interactively through terminal input. Subroutines are named to describe their main function. A description of each subroutine is given in the following sections.

MAIN PROGRAM - V1086S

-Purpose:

1) Dimensions and allocates space for the main storage arrays.
2) Divides the storage arrays into their component arrays.
   (sets up pointers)
3) Starts and stops the simulation.

-Calls to:

SUTRAP

-Description:

The main routine has five arrays that must be user-dimensioned: DPV, IMV, GV1, GV2, and IMG. These are used for dynamic storage allocation and they contain almost all of the values required for SUTRA-PLOT. DPV contains

double precision real vectors, IMV contains integer matrices and vectors, GV1 and GV2 are real vectors, and IMG is an integer vector. DPV and IMV dimensions are based on the number of nodes (NN) and the number of elements (NE) read from the SUTRA input data list. GV1, GV2, and IMG, which are handled separately, store gridding data and cannot be dimensioned until grid dimensions (IXDIM and IYDIM) are input by the user in subroutine CSET.

The main program initializes flags, then the SUTRA input data list is opened, a check is made for a valid file, and NN and NE are read in. The main program uses NN and NE to set up pointers which allocate the correct amount of space for each of the component arrays contained in the large storage arrays. The pointers determine the position in the storage array of the starting element of each component array. The starting elements are passed to subroutine SUTRAP as calling arguments.

SUBROUTINE SUTRAP

-Purpose:

1) Acts as the primary control for plotting operations and file reading interactively through terminal input.
2) Writes main menu to terminal, reads and acts on user response.

-Called by:

Main program - V1086S

-Calls to:

READ5, NCHECK, QCHECK, SVESET, EDIT, NEWSET, OLDSET, PLOT.

-Description:

SUTRAP receives pointers for all actual arrays and vectors which are dynamically allocated space by the main program. All arrays, except UGRID, UMAT and LNUM, are dummy dimensioned to actual sizes required for the program. UGRID, UMAT and LNUM are dummy dimensioned in subroutine PLOT. One additional vector NODEP, which stores nodes defining a mesh perimeter, is dimensioned to a length of 500. SUTRAP initializes some flags and counters, and calls READ5 to read node coordinates and nodal incidences. The primary function of SUTRAP is to write the 'MAIN MENU' to the user terminal and direct user responses. Subroutines to create (NEWSET), read-in (OLDSET), save (SVESET), or edit (EDIT) set-up files are called based on menu selections. Control for actual plotting is passed to subroutine PLOT when

requested. After the initial plot, either a new SUTRA input data list or new SUTRA output file may be requested. When plotting is finished and program exiting is requested, control returns to the main program.

SUBROUTINE NEWSET

-Purpose:

1) Writes new set-up menu to terminal, reads and acts on user response.

2) Transfers control to appropriate set-up subroutine.

-Called by:

SUTRAP

-Calls to:

NCHECK, ASET, CSET, VSET, MSET.

-Description:

NEWSET writes the 'NEW SET-UP' menu to the user terminal and reads in plot type selection. Subroutine ASET is called to select plot specifications common to all types of plots. Subroutines to input specific plot parameters for contour plots (CSET), vector plots (VSET), and mesh plots (MSET) are called based on menu selection.

SUBROUTINE ASET

-Purpose:

1) Prompts for and reads plotting parameters common to all plots.

-Called by:

NEWSET

-Calls to:

QCHECK

-Description:

ASET prompts the user for plot size dimensions, axis dimensions, and axis labeling used in all types of plots. Program control returns to NEWSET.

SUBROUTINE CSET

-Purpose:

1) Prompts for and reads parameters for contour plots.

-Called by:

NEWSET

-Calls to:

NCHECK, QCHECK.

-Description:

CSET prompts the user for parameters used in contour plotting. Program control is then returned to NEWSET.

SUBROUTINE MSET

-Purpose:

1) Prompts for and reads parameters for mesh plots.

-Called by:

NEWSET

-Calls to:

NCHECK

-Description:

MSET prompts the user for parameters used in finite-element mesh plotting. Program control is then returned to NEWSET.

SUBROUTINE VSET

-Purpose:

1) Prompts for and reads parameters for vector plots.

-Called by:

NEWSET

-Calls to:

NCHECK, QCHECK

-Description:

VSET prompts the user for parameters used in velocity vector plotting. Sets default four-digit code (1221) for vector arrowhead. Program control is then returned to NEWSET.

SUBROUTINE OLDSET

-Purpose:

1) Reads set-up file from disk.

-Called by:

SUTRAP

-Calls to:

QCHECK

-Description:

OLDSET prompts for and reads in the pathname of a set-up file previously stored on disk. If the pathname is invalid, an error message is displayed and the program will prompt for another pathname. OLDSET reads the set-up file and returns control to SUTRAP.

SUBROUTINE SVESET

-Purpose:

1) Writes set-up file to disk.

-Called by:

SUTRAP

-Calls to:

No calls

-Description:

SVESET prompts for and opens a filename for saving a set of plotting parameters. If the filename is invalid, or the file already exists, an error message is displayed and the program will prompt for another name. SVESET will not write over an existing file. Set-up files no longer needed must be deleted after exiting SUTRA-PLOT. Plotting parameters specified by the user are saved in three sections. Section 1 saves parameters common to all plots. Section 2 saves parameters for the specific type of plot. Section 3 saves data calculated by two of the plotting subroutines. If finite-element gridding has been used successfully in a contour plot, an array which locates grid points in the finite-element mesh is also saved. If a finite-element mesh perimeter has been plotted, an array of the nodes defining the perimeter is saved.

SUBROUTINE EDIT

-Purpose:

1) Writes edit menus to terminal and reads user responses.

2) Interactively changes plotting parameters.

-Called by:

SUTRAP

-Calls to:

NCHECK

-Description:

EDIT is a simple menu-driven routine to allow interactive modification of any of the plotting parameters while running SUTRA-PLOT. EDIT writes menus containing the parameter values. The number of the menu option must first be selected, then the new parameter value is entered by the user. EDIT makes use of free formats for terminal input except for program flags which must be entered as integers. Error checking is employed for all input. Modifications made in EDIT remain active until the parameter is re-modified or a new set-up file is read in.

SUBROUTINE PLOT

-Purpose:

1) Initializes and terminates DISSPLA.

2) Plots axes and labels.

3) Passes program control to appropriate plot subroutine.

-Called by:

SUTRAP

-Calls to:

READ6, OUTDEV, *RESET, *SETDEV, *NBRDR, *GRACE, *PAGE, *AREA2D, *HEIGHT, *XNAME, *YNAME, *YAXANG, *GRAF, *THKFRM, *FRAME, MESHP, VECPLT, KONTUR, *ENDPL, *DONEPL, QCHECK

Note: * indicates DISSPLA subroutine

-Description:

PLOT initiates plotting and controls plotting subroutines. Three arrays which contain grid data are dimensioned in PLOT. UMAT is a two-dimensional array dummy dimensioned to the number of rows (IYDIM) by the number of columns (IXDIM) specified by the user. UGRID, and LNUM are vectors dummy

dimensioned to the number of grid points calculated by IXDIM*IYDIM. A file named 'PLOT.OUT' is opened and all error messages and diagnostics from DISSPLA are written to this file. PLOT prompts for a SUTRA output filename and calls subroutine READ6 which reads the SUTRA output file for the appropriate data indicated by the type of plot requested. At this point all necessary data has been read in and the plot can be started.

PLOT calls OUTDEV to select an output device. Then DISSPLA is initialized and, if appropriate, axes and labels are drawn. PLOT utilizes the self-counting feature of DISSPLA to print the axis labels. A short routine determines the end of the label character string, then concatenates a '$' to the end. PLOT then calls the appropriate subroutine to plot contours (KONTUR), velocity vectors (VECPLT), or a finite-element mesh (MESHP). After a plot is made, control returns to PLOT. At this point, the user is able to request a plot of another time step from the active SUTRA output file; otherwise control is returned to SUTRAP.

SUBROUTINE READ5

-Purpose:

1) Reads node coordinates and nodal incidence list from SUTRA input data list.

-Called by:

SUTRAP

-Calls to:

SKIP

-Description:

READ5 reads the SUTRA input data list specified by the user. The original structure of the data list is assumed to be intact. The appropriate variables are read from lines 1-7 of the data list to calculate the location of the node coordinates and nodal incidence list in file. READ5 calls subroutine SKIP to skip over unused data lines. Node coordinates are read, then multiplied by the nodewise scale factors. Minimum and maximum x- and y-coordinates are calculated. Then PLOT skips to the last part of the file and reads the nodal incidence list.

SUBROUTINE READ6

-Purpose:

1) Reads simulation results from SUTRA output file.

-Called by:

SUTRAP

-Calls to:

SKIP, QCHECK

-Description:

READ6 reads the SUTRA output listing specified by the user. The original structure of the listing is assumed to be intact. READ6 searches for specific character strings in the listing to locate appropriate data, and calls subroutine SKIP to skip over unused data lines. First, two lines are read near the beginning of the file to determine if any part of the output data is 'steady-state' If the selected plot is steady-state, a menu is displayed and the user may then plot the data or abort the plot. Aborted plots return program control to SUTRAP. If an output with transient data is indicated, READ6 searches for ITMAX, the maximum number of time steps in the simulation, and NPRINT, the interval for printed output. READ6 then searches for the output from the first time step, which should always be time step 1. A plot option menu is displayed indicating the printed time step interval, maximum time steps, the time step where the program pointer is, and the plotting options. The user may plot this time step (program control returns to PLOT), skip to the next time step in the output file or jump to a specified time step (control remains in READ6), or abort the plot (control returns to SUTRAP). For either steady-state or transient data, when 'plot' is selected by the user, the appropriate section of the output is located and read. Program control then returns to PLOT.

SUBROUTINE OUTDEV

-Purpose:

1) Writes output device menu to terminal and reads user response.

2) Nominates output device.

-Called by:

PLOT

-Calls to:

NCHECK, *TAB, *HIPLOT, *HWSCAL, *TK4114, *COMPRS

Note: * indicates DISSPLA subroutine.

-Description:

OUTDEV selects the device to which the graphic output of DISSPLA will be sent. This subroutine is installation dependent and will normally be modified by the user to accommodate available devices. The DISSPLA manuals should be consulted for currently supported output devices. The OUTDEV subroutine in Attachment E can be modified, or replaced by any similar device nominating routine. In OUTDEV, the user selects a device from a numbered menu. The number of the device (IDEV) and program control is returned to PLOT.

SUBROUTINE KONTUR

-Purpose:

1) Draws contour plots.

-Called by:

PLOT

-Calls to:

GRIDR, *BGNMAT, *GETMAT, *ENDMAT, *BCOMON, *CONMIM, *CONMAK, *CONLIN, *CONANG, *RASPLN, *CONTUR

Note: * indicates DISSPLA subroutine.

-Description:

KONTUR first re-scales the data (array U) to be contoured if requested. Then KONTUR checks the gridding options. If finite-element gridding was selected, subroutine GRIDR is called. KONTUR passes U to GRIDR, and GRIDR returns the gridded data in vector UGRID. UGRID is then loaded into array UMAT. If no gridding is required, U is loaded directly into UMAT. If DISSPLA gridding was selected, three DISSPLA routines are called. KONTUR passes the grid dimensions (IXDIM and IYDIM) to BGNMAT, and node coordinates (X and Y) and U to GETMAT. DISSPLA returns gridded data in UMAT after a call to ENDMAT. The contours are then plotted using various DISSPLA routines.

SUBROUTINE GRIDR

-Purpose:

1) Grids irregular data using a finite-element interpolation.

-Called by:

KONTUR

-Calls to:

No calls

-Description:

The gridding subroutine GRIDR is divided into two parts. The first part matches elements of the finite-element mesh with included grid points through an exhaustive search procedure. A list of these locations are saved in an array of element numbers, LNUM and can be saved in a set-up file and re-used to contour with the same finite-element mesh and grid density. The second part of GRIDR is a finite-element interpolation routine which uses basis functions to calculate values at each grid point from node values in the finite-element mesh.

A flag at the beginning of GRIDR determines whether a grid location array (LNUM) has been previously calculated, and, if so, the element/grid point matching routine is skipped. Otherwise, the element which contains each of the grid points must be located. This type of search is commonly known as a 'point in polygon' problem. Knowing the coordinates of the four nodes in the element, GRIDR must determine if the coordinates of the grid point fall within the limits of any of the elements. The elements must be checked one at a time. To speed up this search process, an approximate location of the grid point is determined. First, the maximum x or maximum y coordinate of each element is determined, depending on the direction which has the fewest grid points, and stored in array XYMAX. XYMAX is then sorted into ascending numerical order using an index array IXY. Then the coordinates of a grid point are compared, in indexed order, to XYMAX. If the grid point coordinate is greater than the maximum of an element, that element is not specifically checked. Once this test is not met, the remaining elements in XYMAX are checked.

The checking algorithm to match elements with grid points is straightforward. Four line segments are constructed from the grid point to each of the four nodes of the element. The four adjacent angles formed by the line segments are calculated. If the sum of the angles is 360 degrees, then the

grid point is assumed to fall within the element. Two special cases must be tested; 1- The grid point coincides with a node. When contructing line segments, if the length of the line segment is zero, then the grid point coincides with that node. 2- The grid point lies on an element side. If the angle between two adjacent line segments is 180 degrees, then the grid points lines on a side of the element. After the grid point is matched to an element, the element number is saved in LNUM, and the interpolation routine begins.

The interpolation used in GRIDR calculates a value at the grid point using basis functions and a numerical algorithm equivalent to that used in SUTRA methodology. The resulting values at each grid point are calculated from the elevation of the true curved surface used by SUTRA representing U over an element (fig. 6.1). The interpolated value of U at every grid point is exact, regardless of the fineness of the gridding used or the spacing in the original finite-element mesh.

For coefficients (i.e., concentration, temperature, pressure) which have been discretized nodewise over a finite-element mesh, the equation which gives values of the coefficients, may be expressed for the two-dimensional mesh as (Voss, 1984 p. 73):

$$U(x,y,t) = \sum_{i=1}^{NN} U_i(t)\ \phi_i(x,y) \qquad (6.1)$$

where the nodes have been numbered from one to NN (total number of nodes in the mesh). There are NN coefficients, $U_i(t)$, each of which is assigned a value at the coordinates (x_i,y_i) of node i. The functions $\phi_i(x,y)$ are known as the 'basis functions'. It is the basis functions that spread values of U between the nodes when U is defined only at the nodal points (fig. 6.2).

One basis function $\phi_i(x_i,y_i)$ is defined for each node, i, of the NN nodes in the mesh. Equation (6.1) is also valid over a single element (Voss, written commun., 1986). Values at any point (x,y) in an element may be calculated from (6.1) by the following:

$$U(x,y) = \sum_{j=1}^{4} U_j\ \phi_j(\xi,\eta) \qquad (6.2)$$

where ξ and η are the local coordinates as defined by Voss (1984), and where the subscript j now refers to each of the four nodes in an element and ϕ_j is

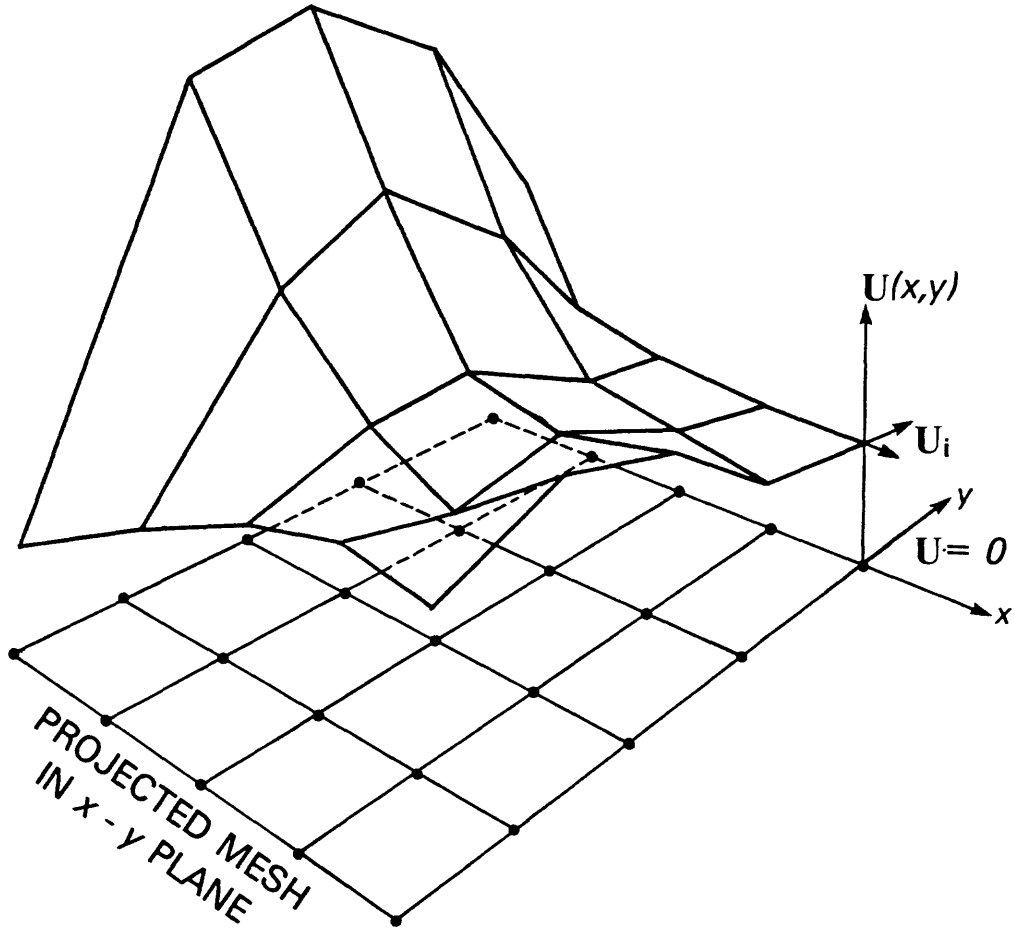


Figure 6.1. Nodewise representation of variable U(x,y) (modified from Voss, 1984).

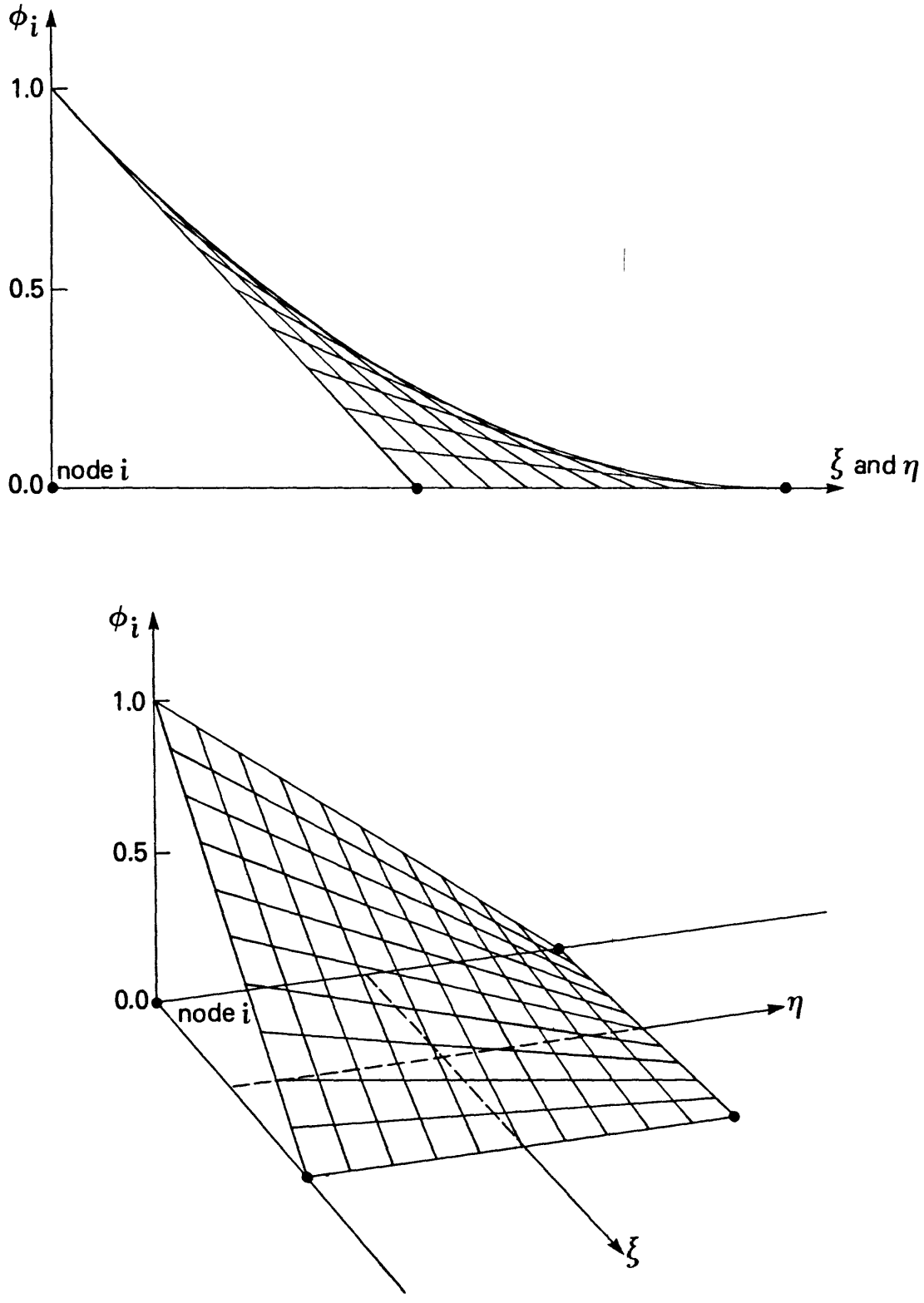


Figure 6.2 Perspective of basis function $\phi_i(\xi,\eta)$ over an element at node i (modified from Voss, 1984).

the local basis function defined at (ξ,η) for the jth node in an element. To calculate the value of a coefficient, U, at any point (x,y) in an element, the values of U_j at the corner nodes must be known; and the four basis functions corresponding to the corner nodes for the element must be determined at the point (ξ,η). The global coordinate system (x,y) can be related to the local coordinate system by:

$$x = \sum_{i=1}^{4} \phi_i(\xi,\eta)\ x_i \qquad (6.3)$$

$$y = \sum_{i=1}^{4} \phi_i(\xi,\eta)\ y_i \qquad (6.4)$$

where x and y are the global coordinates of the grid point located in element i, x_i and y_i are the coordinates of the corner nodes of element i, and ϕ_i is the basis function defined at ξ and η for node i. The basis functions ϕ_i (i=1,2,3,4) are defined as:

$$\phi_1 = 1/4\ (1-\xi)(1-\eta) \qquad (6.5a)$$

$$\phi_2 = 1/4\ (1+\xi)(1-\eta) \qquad (6.5b)$$

$$\phi_3 = 1/4\ (1+\xi)(1+\eta) \qquad (6.5c)$$

$$\phi_4 = 1/4\ (1-\xi)(1+\eta) \qquad (6.5d)$$

Substituting equation 6.5(a-d) for ϕ_i in equations 6.3 and 6.4 and expanding the result gives:

$$x = 1/4[(1-\xi)(1-\eta)x_1+(1+\xi)(1-\eta)x_2+(1+\xi)(1+\eta)x_3+(1-\xi)(1+\eta)x_4] \qquad (6.6)$$

$$y = 1/4[(1-\xi)(1-\eta)y_1+(1+\xi)(1-\eta)y_2+(1+\xi)(1+\eta)y_3+(1-\xi)(1+\eta)y_4] \qquad (6.7)$$

Equations 6.6 and 6.7 are solved simultaneously for ξ and η using a Newton-Raphson iterative routine. Equations 6.5(a-d) are used to evaluate ϕ_i (i=1,2,3,4).

The value at the grid point, U(x,y) , is then calculated by rewriting (6.2) as:

$$U(x,y) = U_1 \phi_1 + U_2 \phi_2 + U_3 \phi_3 + U_4 \phi_4 \qquad (6.8)$$

After the values at all the grid points have been calculated, program control is returned to KONTUR.

SUBROUTINE VECPLT

-Purpose:

1) Calculates, scales and draws velocity vectors.

-Called by:

PLOT

-Calls to:

*RLVEC

Note: * indicates DISSPLA subroutine.

-Description:

VECPLT calculates the maximum (VMAX) and minimum (VMIN) vector magnitudes. The plot dimensions are scaled, and element centroids are calculated. The vector magnitudes and directions are scaled to user specifications. If the magnitude of the vector is less than the user specified minimum fraction of the maximum, VLSCL, the vector is not drawn. In addition, ISKIP is used as an index to skip over vectors at regular intervals. The vector is drawn with the tail of the arrow at the element centroid. The vector scaling is described separately below.

Vector magnitude scaling.--Vector magnitudes, VMAG4 are linearly scaled to the plotted page by:

$$VMAG4 = VMAG4/VMAX * VPSCL \qquad (6.8)$$

Dividing by VMAX in equation 6.8 normalizes VMAX to one, and multiplying by VPSCL gives the plotted size of the largest vector in inches (user selected).

Logarithmic scaling is obtained by the following relation for the vector magnitude, VMAG4:

$$VMAG4 = 1 \; / \; 1 - \; [\; ALOG10(VMAG4/VMAX) \;] \qquad (6.9)$$

Equation (6.9) scales each vector such that the VMAX is normalized to one, and for each reduction in magnitude by $1/10^n$, the plotted length is reduced by $1/(n+1)$. This relation is shown graphically in figure 6.3. VMAG4 is then multiplied by VPSCL to give the plotted size in inches (user selected).

Vector angle scaling.--In plots where the coordinate scales are changed relative to the scaling in the model, the direction of the fluid velocity vectors should be corrected to conform to the new scaling. For example, if vertical cross-sections are plotted with an exaggerated vertical scale, the flow pattern is distorted (Everdingen, 1963). This is analogous to the problems which have been encountered when constructing flow patterns from potential nets on diagrams with an exaggerated vertical scale (Freeze, 1966). When the velocity vector directions calculated for an unexaggerated domain are plotted on an exaggerated scale, the result is a distorted sense of the direction of flow and misinterpretations of the overall flow field may result.

Figure 6.4a shows a schematic finite-element mesh with velocity vectors indicating flow occurring diagonally across the mesh. In figure 6.4b, the mesh has been vertically exaggerated by the factor of 5. The unadjusted solid arrows suggest that the flow will intersect near the center of the right side of the elements. The dashed arrows, which have been adjusted for the exaggerated vertical scale, correctly indicate that the flow will intersect the upper right corner of each element.

VECPLT adjusts the vector angle be multiplying the y-component of the vector by the ratio of the y-scale and x-scale of plot. A new angle is calculated from the original x-component and the scaled y-component. The magnitude is not affected by this calculation.

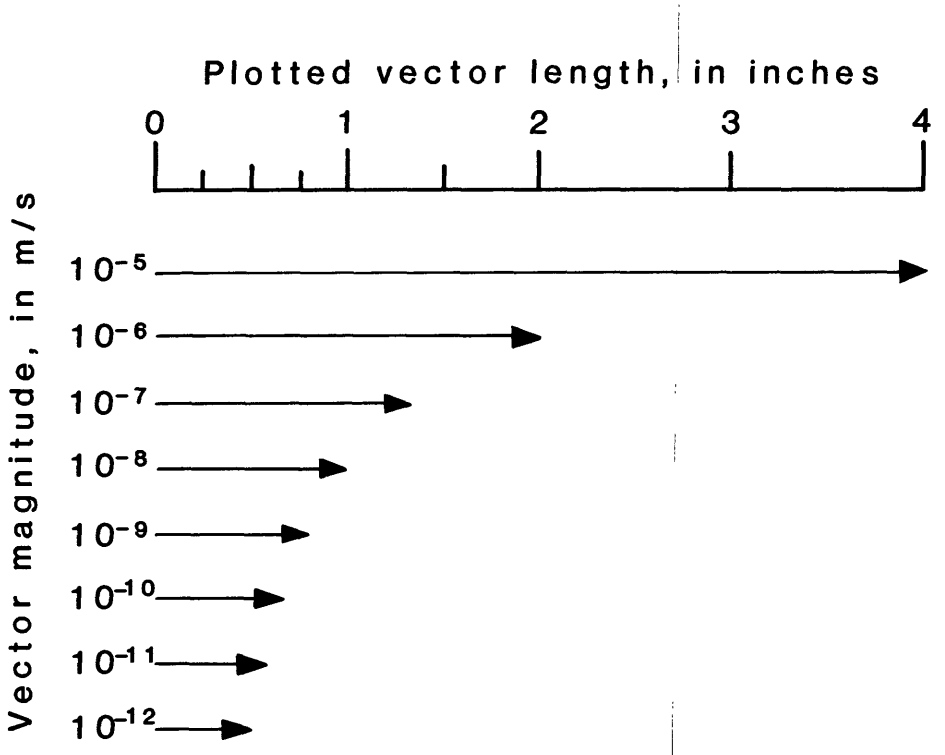


Figure 6.3. Graphic representation of logarithmically-scaled velocity vectors when largest plotted vector is specified to be 4 inches.

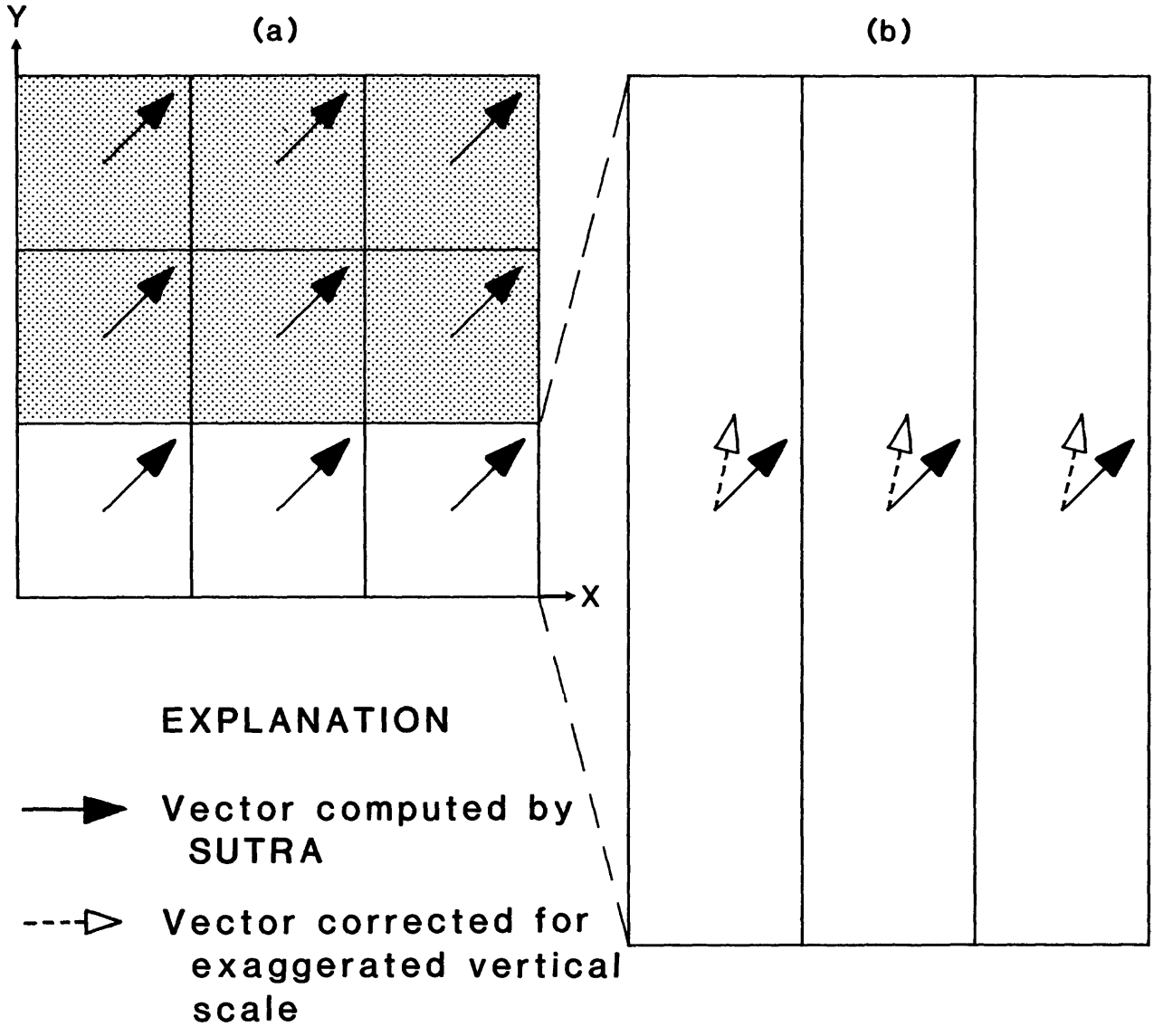


Figure 6.4. (a) Velocity vectors plotted with equal x and y scaling plotted on schematic finite-element mesh,
(b) Velocity vectors in bottom row of elements plotted with exaggerated (5:1) y-axis.

SUBROUTINE MESHP

-Purpose:

1) Draws finite-element mesh or mesh perimeter.

2) Calculates and saves mesh perimeter nodes.

-Called by:

PLOT

-Calls to:

*RLVEC

Note: * indicates DISSPLA subroutine.

-Description:

MESHP calculates plot dimensions, then determines how the mesh is to draw. MESHP uses the DISSPLA routine RLVEC to draw lines between pairs of node coordinates. If a perimeter is requested and the perimeter nodes have been previously calculated, nodes are read from NODEP and used to draw the perimeter. If all sides of all elements are to be drawn, all combinations of pairs of nodes defining a side are determined from the incidence list (four pairs for each element) and each side is drawn.

The logic to eliminate drawing of duplicate sides or to draw the mesh perimeter is straightforward. A single DO loop controls both options. The variable KOUNTA controls which option is executed. After reading a pair of nodes from the incidence list, but before drawing the side defined by the pair, KOUNTA pairs of nodes are re-read from the beginning of the incidence list. If the same combination of two nodes occurs in the list, the side is not drawn. If KOUNTA is equal to the number of sides that have already been plotted, only previously drawn sides will be skipped, and the entire mesh will be drawn without retracing sides. If KOUNTA is equal to the total number of possible sides (NE*4) in the mesh, all node pairs which occur more than once in the list will be eliminated from the plot, and only the mesh perimeter will be drawn.

SUBROUTINE SKIP

-Purpose:

1) Reads dummy input to skip a line of data.

-Called by:

OLDSET, READ5, READ6

-Calls to:

No calls

-Description:

SKIP receives a unit number (IUNIT) from the calling routine. A dummy line is read from IUNIT, and program control returns to the calling routine.

SUBROUTINE QCHECK

-Purpose:

1) Reads and checks for a valid response to a SUTRA-PLOT query (Y/N?) requiring a yes or no user response.

-Called by:

V1086S, NEWSET, CSET, VSET, OLDSET, PLOT, READ6

-Calls to:

No calls

-Description:

QCHECK reads in a user response to a (Y/N?) query generated in the calling routine. The response is checked for a "Y" or "N" (upper or lower case) and then returns ICODE with a "1" for yes, and a "0" for no. Any other response results in error messages until either a "Y" or "N" is entered by the user. Program control is then returned to the calling routine.

SUBROUTINE NCHECK

-Purpose:

1) Reads and checks for a valid response to a SUTRA-PLOT prompt requiring a user response to a numbered menu option.

-Called by:

V1086S, NEWSET, CSET, MSET, VSET, EDIT, OUTDEV

-Calls to:

No calls

-Description:

NCHECK reads in a user response to menu options in the calling routine. NCHECK receives the total number of valid menu options available (NNUM), and passes back the user response, IRSPN. The user may select any numbered option, or "X" to exit the menu (IRSPN=99), or "M" to have the menu re-displayed (IRSPN=0). Program control returns to the calling routine.

REFERENCES

Everdingen, R. O. van, 1963, Groundwater flow-diagrams in sections with exaggerated vertical scale: Geological Survey of Canada, Dept. of Mines and Technical Surveys, Paper 63-27, 21 p.

Freeze, R. A. and P. A. Witherspoon, 1966, Theoretical analysis of regional groundwater flow: 1. Analytical and numerical solutions to the mathematical model: Water Resources Research, v. 2, no. 4, p. 641-655.

Integrated Software Systems Corp., 1984, DISSPLA users manual, version 9.2: Integrated Software Systems Corp., San Diego, variously paged.

Voss, C. I., 1984, SUTRA: A finite element simulation model for saturated-unsaturated, fluid density dependent ground-water flow with energy transport or chemically reactive single species solute transport: U.S. Geological Survey Water-Resources Investigations Report 84-4369, 409 p.

ATTACHMENT A. Set-up file data instructions

SET-UP DATA FILE LISTING

---------- Group I (page dimensions and axis settings) ----------

Line	Variable	Format	Column	Description
1	PLOTYPE	A4	1-4	Text flag for type of plot. Also flag for reading appropriate plot parameters in Group II.
2	LXNAME	A59	1-59	Text for label printed below x-axis.
3	LYNAME	A59	1-59	Text for label printed below y-axis.
4	PAGEX	F15.5	1-15	Page dimensions, in inches, in x-direction. Together with PAGEY, defines area within which all plotting must fit.
4	PAGEY	F15.5	16-30	Page dimensions, in inches, in y-direction.
5	XAXIS	F15.5	1-15	Length of x-axis in inches. Together with YAXIS, defines the area where data curves will be drawn.
5	YAXIS	F15.5	16-30	Length of y-axis in inches.
6	XINT	F15.5	1-15	Interval, in scaled model units, at which tick marks and number labels will be drawn below the x-axis.
6	YINT	F15.5	16-30	Interval, in scaled model units, at which tick marks and number labels will be drawn along the y-axis.
7	XMIN	F15.5	1-15	Minimum x-coordinate in scaled model units.
7	YMIN	F15.5	16-30	Minimum y-coordinate in scaled model units.
8	XMAX	F15.5	1-15	Maximum x-coordinate in scaled model units.
8	YMAX	F15.5	16-30	Maximum y-coordinate in scaled model units.
9	B L A N K L I N E			

Set-up file data instructions -- continued

Line	Variable	Format	Column	Description
	Group II (Contour plots only)			
10	CONTYPE	A4	1-4	Text flag for the type of contour plot.
10	CONTX	A4	10-14	Text string used to locate specific types of data in the SUTRA OUTPUT file.
11	IXDIM	I10	1-10	Number of columns in contouring grid (x-direction).
11	IYDIM	I10	11-20	Number of rows in contouring grid (y-direction).
11	IDIR	I10	21-30	
11	NUMDIR	I10	31-40	Mesh numbering flag. 0=mesh numbered along rows (x-direction); 1=mesh numbered along columns (y-direction).
12	IGRID	I10	1-10	Type of gridding flag. 1=DISSPLA gridding; 2=Finite-element gridding; 3=No gridding.
12	IZIN	I10	11-20	Flag to select source of contour interval. 0=interval is set by ZINCR (user selected); 1=DISSPLA selected.
12	ISCAL	I10	21-30	Data scaling flag. 0=data not scaled; 1=data scaled using UBASE and UMULT.
13	MODE	I10	1-10	Flag to specify type of contour line to be drawn. 1=dot; 2=dash; 3=chain-dotted; 4=chain-dashed; 5=solid.
13	LBLFLG	I10	11-20	Contour line labeling flag. 1=labels drawn; 2=no labels are drawn.
13	ITHICK	I10	21-30	Contour line thickness in interger multiples of 0.01 inch. (e.g. 5=0.05 inch).
14	ZINCR	F15.5	1-15	User selected contour line interval.
14	UBASE	F15.5	16-30	Factor for re-scaling contoured data. See UMULT below.
14	UMULT	F15.5	31-45	Factor for re-scaling contoured data. The value to be plotted is calculated by: Plotted value = (true value / UBASE) * UMULT.
	(Finite-element gridding only)			
15*	LNUM(I)	16I5	1-80	List of element numbers matched to grid points calculated in GRIDR. This list is written to set-up file after first plot using finite-element gridding and can only be re-used with the original SUTRA INPUT data list and grid dimensions.

* one line plus one line for each (IXDIM*IYDIM+16)/16 (integer arithmetic) grid points.

Set-up file data instructions -- continued

---------- Group II (Velocity vector plots only) ----------

Line	Variable	Format	Column	Description
10	IVEC	I10	1-10	A four digit DISSPLA code which identifies the type of arrowhead drawn on the vectors. Arrowhead characteristics are normally changed interactively; however, to change arrowhead characteristics in the in the set-up file refer to the DISSPLA manuals for coding options.
10	ILSCL	I10	11-20	Vector length scaling flag. 1=linear; 2=logrithmic.
10	IASCL	I10	21-30	Vector direction scaling flag. 0=no scaling; 1=angles scaled to plot.
10	ISKIP	I10	31-40	Number of vectors skipped when plotting. Only every ISKIP(th) vector is drawn (vector thinning option).
11	VPSCL	F10.4	1-10	Plotted length of largest vector in inches.
11	VLSCL	E10.4	11-20	Fractional length of largest vector plotted. Vector magnitudes less than VLSCL/VMAG4 will not be drawn (vector thinning option).

---------- Group II (Mesh plots only) ----------

Line	Variable	Format	Column	Description
10	ISIDE	I10	1-10	Flag to select type of meshplot to draw. 1=all sides of all elements will be drawn; 2=mesh drawn without duplicating sides; 3=draw perimeter of mesh only.
	(Perimeter plots only)			
11	NCOUNT	I5	1-5	Number of perimeter nodes calculated from first plot of mesh perimeter.
12*	NODEP	16I5	1-80	List of perimeter node numbers.

* one line plus one line for each (NCOUNT+16)/16 (integer arithmetic) perimeter nodes.

ATTACHMENT B. Sample set-up file for example 5.1

```
CONT
DISTANCE, IN THOUSANDS OF FEET$
DISTANCE, IN THOUSANDS OF FEET$
                10.00000       12.00000
                 8.00000       10.00000
              4000.00000     5000.00000
                 0.00000        0.00000
             16000.00000    20000.00000
------------------------------
PRES      P  R
         17         21          0          0
          3          1          0
          5          1          1
      250.00000         1.00000  1000000.00000
```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ATTACHMENT C. Installation CPL file listings

Filename: SP_COMPILE.CPL

```
/* CPL ROUTINE TO COMPILE ENTIRE SUTRA-PLOT CODE IN F77.
/* -TO EXECUTE THIS ROUTINE, JUST TYPE " cpl sp_compile " FROM PRIMOS.
&debug &echo com
F77 V1086S.F77 -BIG
F77 SUTRAP.F77 -BIG
F77 NEWSET.F77 -BIG
F77 ASET.F77 -BIG
F77 CSET.F77 -BIG
F77 MSET.F77 -BIG
F77 VSET.F77 -BIG
F77 OLDSET.F77 -BIG
F77 SVESET.F77 -BIG
F77 EDIT.F77 -BIG
F77 PLOT.F77 -SAVE -BIG
F77 READ5.F77 -BIG
F77 READ6.F77 -SAVE -BIG
F77 OUTDEV.F77 -SAVE -BIG
F77 KONTUR.F77 -SAVE -BIG
F77 GRIDR.F77 -SAVE -BIG
F77 VECPLT.F77 -SAVE -BIG
F77 MESHP.F77 -SAVE -BIG
F77 SKIP.F77 -BIG
F77 QCHECK.F77 -BIG
F77 NCHECK.F77 -BIG
&debug &no_echo com
type
type
type            SP COMPILE Completed.
&return
```

Installation CPL file listings -- continued

```
Filename: SP_LOAD.CPL
---------------------

/* CPL ROUTINE TO CREATE LOAD MODULE FOR SUTRA-PLOT CODE.
/* -TO RUN ROUTINE, JUST TYPE " cpl sp_load " FROM PRIMOS.
DELETE V1086S.SEG
&data SEG -LOAD
   LO V1086S
   LO SUTRAP
   LO NEWSET
   LO ASET
   LO CSET
   LO MSET
   LO VSET
   LO OLDSET
   LO SVESET
   LO EDIT
   LO PLOT
   LO READ5
   LO READ6
   LO OUTDEV
   LO KONTUR
   LO GRIDR
   LO VECPLT
   LO MESHP
   LO SKIP
   LO QCHECK
   LO NCHECK
   LI DISSPLA
   LI
   ST 177777
   SAVE
   MAP V1086S.MAP
   QUIT
&end
type
type            SP_LOAD Complete......V1086S.SEG has been created.
LD @@.SEG -DET -SORTD
&return
```

ATTACHMENT D. Definition of program variables

VARIABLE	TYPE	DESCRIPTION
A1	REAL*8	Coefficient of implicit equation in GRIDR
A2	REAL*8	Coefficient of implicit equation in GRIDR
AX	REAL*4	Intermediate storage value in Newton-Raphson routine
AY	REAL*4	Intermediate storage value in Newton-Raphson routine
B1	REAL*8	Coefficient of implicit equation in GRIDR
B2	REAL*8	Coefficient of implicit equation in GRIDR
BLANK	CHARACTER *1	The character 'blank' in PLOT
BX	REAL*4	Intermediate storage value in Newton-Raphson routine
BY	REAL*4	Intermediate storage value in Newton-Raphson routine
CONTX	CHARACTER*4	Type of contour plot; concentration, pressure,or temperature in SUTRA output
CONTYPE	CHARACTER*4	Type of contour plot; concentration, pressure,or temperature in SET-UP file
CX	REAL*4	Intermediate storage value in Newton-Raphson routine
CY	REAL*4	Intermediate storage value in Newton-Raphson routine
DELETA	REAL*4	Change in ETA between iterations
DELXSI	REAL*4	Change in XSI between iterations
DET	REAL*4	Determinant in Newton-Raphson routine
DPV	REAL*8	Vector containing double precision array storage
DXL	REAL*4	Gridding division in x-direction
DYL	REAL*4	Gridding division in y-direction
DUMMY	CHARACTER*1	Dummy string character in SKIP
ETA	REAL*4	Local node coordinate
ETA0	REAL*4	Initial guess for ETA in Newton-Raphson routine
F10	REAL*4	Function relating global x-coordinate to local coordinates
F20	REAL*4	Function relating global y-coordinate to local coordinates
FP11	REAL*4	Derivative of F10 with respect to XSI
FP12	REAL*4	Derivative of F10 with respect to ETA
FP21	REAL*4	Derivative of F20 with respect to XSI
FP22	REAL*4	Derivative of F20 with respect to ETA
GV1,GV2	REAL*4	Gridding data storage array
IARRW	INTEGER*4	Code for vector arrowhead type in EDIT
IASCL	INTEGER*4	Flag: set(1) for rescaling vector direction

Definition of program variables -- continued

VARIABLE	TYPE	DESCRIPTION
ICODE	INTEGER*4	Flag: set(1) for yes/no response to menu query
IDEF	INTEGER*4	Flag: set(1) changes default contour line characteristics
IDEV	INTEGER*4	Code for output device selection
IDIR	INTEGER*4	Flag: indicates direction with lessor number of gridpoints; set(1)=x-direction
IFLAG	INTEGER*4	Flag: set(1) indicates printout file has been previously read in READ6
IGRID	INTEGER*4	Code for method of gridding data
ILSCL	INTEGER*4	Code for vector length scaling
IMOD	INTEGER*4	Flag: set(1) indicates status of modified setup files
IMG,IMV	INTEGER*4	Vector containing array storage
INDXT	INTEGER*4	Intermediate storage for index array IXY
INDX	INTEGER*4	Loop index to control number of element side plotted
IN	INTEGER*4	Incidence list array (NE,4) in COMMON/ALL/
IOLD	INTEGER*4	Code to read existing SET-UP file
IOPTN	INTEGER*4	Option for numbered menu input from terminal in CSET,SUTRAP
IP1,IP2	INTEGER*4	Array pointers passed to SUTRAP
IPLOT	INTEGER*4	Flag: set(1) when plot requested from terminal input
IQUIT	INTEGER*4	Flag: set(1) indicates program termination status
IR	INTEGER*4	Element counter for sort routine in GRIDR
IREAD	INTEGER*4	Flag: set(1) re-reads SUTRA output datafile without prompt
IRSPN	INTEGER*4	Number of menu option input at terminal
ISAVE	INTEGER*4	Flag: set(1) indicates SET-UP file saved to disk
ISCAL	INTEGER*4	Flag: set(1) indicates contour scaling factors in effect
ISTEP	INTEGER*4	Time step currently being read in READ6
ISSFLO	INTEGER*4	Steady-state/transient flag read from SUTRA input dataset
ISTAT	INTEGER*4	Flag: set(1) when errors detected in I/O
ISIDE	INTEGER*4	Code for type of meshplot
ISIZE	INTEGER*4	Code for plotted length of velocity vector
ISKIP	INTEGER*4	Code for method of vector thinning
ITHICK	INTEGER*4	Contour line thickness in hundreds of an inch
ITHIN	INTEGER*4	Thinning option flay that sets ISKIP and VLSCL
ITEMP	INTEGER*4	Temporary storage for user response in EDIT

Definition of program variables -- continued

VARIABLE	TYPE	DESCRIPTION
ITER	INTEGER*4	Iteration counter
ITERMAX	INTEGER*4	Maximum allowed number of iterations in Newton-Raphson routine
ITMAX	INTEGER*4	Maximum allowed number of time steps in simulation read from SUTRA printout
ITYPE	INTEGER*4	Code for type of velocity vector arrowhead
IUNIT	INTEGER*4	Unit number in SKIP
IUNSAT	INTEGER*4	Saturated/unsaturated flag read from SUTRA input data file
IVALUE	INTEGER*4	Temporary value of data input from terminal in CSET,EDIT
IVALX	INTEGER*4	Temporary value of grid x-dimension input from terminal in EDIT
IVALY	INTEGER*4	Temporary value of grid x-dimension input from terminal in EDIT
IVAR	INTEGER*4	Code to set gridding options in EDIT
IVEC	INTEGER*4	Code that identifys type of velocity vector arrowhead
IX	INTEGER*4	Number of characters in x-axis label
IXDIM	INTEGER*4	Number of columns in contouring grid (x-direction)
IXY	INTEGER*4	Index array for sorted element numbers
IY	INTEGER*4	Number of characters in y-axis label
IYDIM	INTEGER*4	Number of columns in contouring grid (y-direction)
IZIN	INTEGER*4	Flag: set(1) uses DISSPLA selected contour interval
JFLAG	INTEGER*4	Flag: set(1) when "JUMP" option initiated
JSTEP	INTEGER*4	Timestep input from terminal for "JUMP" option
KINCID	INTEGER*4	Node incidence list printout flag read from SUTRA input data file
KM	INTEGER*4	Array(12) containing data /2,3,4,1,3,4,1,2,4,1,2,3/ for element sequencing
KN	INTEGER*4	Array(5) containing data /1,2,3,4,1/ for element sequencing
KNODAL	INTEGER*4	Flag: read from SUTRA input data; set(1) indicates full printout
KOUNT	INTEGER*4	Line counter in READ6
KOUNTA	INTEGER*4	Node pair counter in MESHP
KOUNTB	INTEGER*4	Node pair counter in MESHP
KPLOT	INTEGER*4	Flag: set(>0) indicates pressure or temperature/concentration plot printout
KPLOTP	INTEGER*4	Flag: read from SUTRA input data; set(1) indicates pressure plot printout
KPLOTU	INTEGER*4	Flag: read from SUTRA input data; set(1) indicates temperature/concentration plot printoh
KSTEP	INTEGER*4	Timestep of output data to be read
KVEL	INTEGER*4	Fluid velocity printout flag read from SUTRA input data file

Definition of program variables -- continued

VARIABLE	TYPE	DESCRIPTION
LABEL	CHARACTER*8	Set to LABEL/NO LABEL and passed to DISSPLA
LBLFLG	INTEGER*4	Flag: set(1) draws contour line labels
LINE	CHARACTER*6	Plotted line type passed to DISSPLA
LNUM	INTEGER*4	Array(IXDIM*IYDIM) of element location of grid points
LSTEP	INTEGER*4	Maximum allowed number of time steps read from SUTRA printout
LXTEMP	CHARACTER*60	Temporary x-axis label input from terminal
LXNAME	CHARACTER*60	Text for label printed below x-axis
LYTEMP	CHARACTER*60	Temporary y-axis label input from terminal
LYNAME	CHARACTER*60	Text for label printed below y-axis
MODE	INTEGER*4	Code for type of contour line to be drawn
NCOUNT	INTEGER*4	Node counter in MESHP
NE	INTEGER*4	Number of elements in finite-element mesh
NEWFILE	CHARACTER*40	File name for new SET-UP file
NEX	INTEGER*4	Number of grid blocks (x-direction) in GRIDR
NEY	INTEGER*4	Number of grid blocks (y-direction) in GRIDR
NN	INTEGER*4	Number of node in finite-element mesh
NNUM	INTEGER*4	Number of valid menu options
NODE1	INTEGER*4	First node number of pair to be drawn in MESHP
NODE2	INTEGER*4	Second node number of pair to be drawn in MESHP
NODEA	INTEGER*4	First node number of pair previously drawn in MESHP
NODEB	INTEGER*4	Second node number of pair previously drawn in MESHP
NODEP	INTEGER*4	Array(variable) of mesh perimeter nodes
NOBS	INTEGER*4	Number of observation nodes read from SUTRA input dataser
NDP1,2,etc	INTEGER*4	Array pointers passed to SUTRAP
NP	INTEGER*4	Counter for number of grid points
NPBC	INTEGER*4	Number of pressure boundary conditions in READ5
NPLOT	INTEGER*4	Flag: set(1) indicates plotting with current SET-UP file
NPRINT	INTEGER*4	Printed output cycle (in timesteps) read from SUTRA printout
NSKIP	INTEGER*4	Loop index to control plotting of element sides
NSOP	INTEGER*4	Number of specified fluid source/sink nodes read from SUTRA input data file
NSOU	INTEGER*4	Number of specified energy/solute mass nodes read from SUTRA input data file

Definition of program variables -- continued

VARIABLE	TYPE	DESCRIPTION
NSTEP	INTEGER*4	Loop index to skip plot of selected element sides
NTEMP	INTEGER*4	Node counter in MESHP
NUBC	INTEGER*4	Number of specified temperature/concentration nodes read from SUTRA input dataset
NUMBER	CHARACTER*2	Array(20) consisting of the integers 1-20
NUMDIR	INTEGER*4	Flag: indicates direction of mesh numbering; set(1) indicates numbering along rows
OLDFILE	CHARACTER*40	File name of existing SET-UP file
PAGEX	REAL*4	Plotting page x-dimension
PAGEY	REAL*4	Plotting page y-dimension
PHI	REAL*4	Array of basis functions defined in local coordinates
PLOTNAME	CHARACTER*7	Expanded PLOTYPE written to terminal
PLOTYPE	CHARACTER*4	Text code for type of plot in SET-UP file
PSCALX	REAL*4	Re-scaled XAXIS
PSCALY	REAL*4	Re-scaled YAXIS
Q	REAL*4	Intermediate storage for single value of XYMAX
REPLY	CHARACTER*1	Character flag read from terminal
RINV1	REAL*8	Inverse value of RSQ1
RINV2	REAL*8	Inverse value of RSQ2
RSQ1,RSQ2	REAL*8	Line segment length in GRIDR
RSPNSE	CHARACTER*1	Character code for terminal response to yes/no query
SIMULA	CHARACTER*4	Solute transport simulation type read from SUTRA input dataset
SCALX	REAL*4	Multiplier read from SUTRA input data that scales x-coordinates
SCALY	REAL*4	Multiplier read from SUTRA input data that scales y-coordinates
SSFLO	CHARACTER*6	Character flag set for steady-state flow
SSTRA	CHARACTER*6	Character flag set for transient flow
STRNG	CHARACTER*6	String read from SUTRA output to identify specific data sections
SUTRA	CHARACTER*6	String read from SUTRA input data to validate file
SUTRA5	CHARACTER*40	SUTRA input data file read from terminal
SUTRA6	CHARACTER*40	SUTRA printout file read from terminal
TANGLE	REAL*8	Sum of angles around grid point in GRIDR
THETA	REAL*8	Angle between adjacent line segments in GRIDR
TNAME	CHARACTER*60	Temporary storage for axis labels input from terminal

Definition of program variables -- continued

VARIABLE	TYPE	DESCRIPTION
U	REAL*8	Array(NN) of simulation result values
UBASE	REAL*4	Factor for rescaling contoured data
UGRID	REAL*4	Array(NN) of gridded simulation result values
UMAT	REAL*4	Array(IXDIM*IYDIM) of values passed to DISSPLA
UMULT	REAL*4	Factor for rescaling contoured data
UTX	CHARACTER*4	String read from SUTRA output to identify velocity vector data
U4	REAL*4	Single precision equivalent of U(I)
VALUE	REAL*4	Temporary value of data input from terminal
VANG	REAL*8	Array(NE) of velocity vector angles
VANGN	REAL*4	Re-scaled velocity vector angle
VASCL	REAL*4	Factor for vector angle scaling
VLSCL	REAL*4	Factor for eliminating plot of small velocilty vectors
VMAG	REAL*8	Array(NE) of velocity vector magnitudes
VMAG4	REAL*4	Single precision equivalent of VMAG(I)
VMAX	REAL*4	Maximum value of VMAG
VMIN	REAL*4	Minimum value of VMAG
VPSCL	REAL*4	Plotted length of largest velocity vector in inches
VRLOG	REAL*4	Velocity vector magnitude logarithm
X	REAL*8	Array(NN) of mesh coordinates, x-direction
X1,X2,X3,X4	REAL*4	Intermediate storage for element node coordinates
XAXIS	REAL*4	Length of x-axis on plot
XCENT	REAL*4	X-coordinate of element center
XEND	REAL*4	X-coordinate of endpoint of velocity vector
XINT	REAL*4	X-axis interval for tick marks and labels
XK	REAL*8	X-coordinate of gridpoint
XLK	REAL*8	X-component of line segment length
XMAG	REAL*4	X-component of velocity vector
XMAGF	REAL*4	Re-scaled magnitude of X-component of velocti vector
XMAX	REAL*4	Maximum x-axis coordinate
XMIN	REAL*4	Minimum x-axis coordinate
XN	REAL*4	Minimum value of x-coordinates read from SUTRA input data

Definition of program variables -- continued

VARIABLE	TYPE	DESCRIPTION
XRANGE	REAL*4	XMAX-XMIN
XSGL	REAL*4	Single precision equivalent of array X
XSI	REAL*4	Local node coordinate,
XSI0	REAL*4	Initial guess for ETA in Newton-Raphson routine
XSUM	REAL*4	Sum of four x-coordinates of element
XVALUE	REAL*4	Temporary storage for plotting page length input from terminal
XX	REAL*4	Maximum value of x-coordinates read from SUTRA input data
XYMAX	REAL*8	Array (NE) of maximum value of x- or y-coordinate in an element
Y	REAL*8	Array(NN) of mesh coordinates, y-direction
Y1,Y2,Y3,Y4	REAL*4	Intermediate storage for element node coordinates
YAXIS	REAL*4	Length of y-axis on plot
YCENT	REAL*4	Y-coordinate of element center
YEND	REAL*4	Y-coordinate of endpoint of velocity vector
YINT	REAL*4	Y-axis interval for tick marks and labels
YK	REAL*8	Y-coordinate of gridpoint
YLK	REAL*8	Y-component of line segment length
YMAG	REAL*4	Y-component of velocity vector
YMAGF	REAL*4	Re-scaled magnitude of y-component of velocity vector used to plot
YMAGN	REAL*4	Re-scaled magnitude of y-component of velocity vector used to re-scale angles
YMAX	REAL*4	Maximum x-axis coordinate
YMIN	REAL*4	Minimum x-axis coordinate
YN	REAL*4	Minimum value of y-coordinates read from SUTRA input data
YRANGE	REAL*4	YMAX-YMIN
YSGL	REAL*4	Single precision equivalent of array Y
YSUM	REAL*4	Sum of four y-coordinates of element
YVALUE	REAL*4	Temporary storage for plotting page length input from terminal
YX	REAL*4	Maximum value of y-coordinates read from SUTRA input data
ZINCR	REAL*4	User selected contour line interval

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ATTACHMENT E. Program listing

```
C        SUTRA-PLOT     M A I N   P R O G R A M    VERSION 1086S        A10.....
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * A20.....
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * A30.....
C * *                                                                     * * A40.....
C * *              UNITED STATES GEOLOGICAL SURVEY                        * * A50.....
C * *                 WATER RESOURCES DIVISION                            * * A60.....
C * *                                                                     * * A70.....
C * *        INTERACTIVE GRAPHIC POST-PROCESSING PROGRAM                  * * A80.....
C * *         FOR PLOTTING RESULTS FROM THE USGS SUTRA                    * * A90.....
C * *        GROUNDWATER FLOW AND ENERGY/SOLUTE TRANSPORT                 * * A100....
C * *                  SIMULATION MODEL                                   * * A110....
C * *                                                                     * * A120....
C * *          ----------------------------------------                   * * A130....
C * *         |      S U T R A - P L O T        |                         * * A140....
C * *         | I N T E R A C T I V E  G R A P H I C S |                  * * A150....
C * *          ----------------------------------------                   * * A160....
C * *                                                                     * * A170....
C * *               Version  1086S - October 1986                         * * A180....
C * *                                                                     * * A190....
C * *      Creates graphical output from USGS-SUTRA model.                * * A200....
C * *      Requires SUTRA input data file and printout.                   * * A210....
C * *      Program code is written in Fortran 77 and requires            * * A220....
C * *      loading of DISSPLA graphics library.                          * * A230....
C * *                                                                     * * A240....
C * *      Graphics options- 1) Contour plots:                            * * A250....
C * *                           -Concentration-                           * * A260....
C * *                           -Saturation-                              * * A270....
C * *                           -Pressure-                                * * A280....
C * *                           -Temperature-                             * * A290....
C * *                        2) Velocity vector plots                     * * A300....
C * *                        3) Finite-element mesh plots                 * * A310....
C * *                                                                     * * A320....
C * *      Complete explanation for the use of this code is               * * A330....
C * *      given in:                                                      * * A340....
C * *                                                                     * * A350....
C * *      Souza, William R., 1987, Documentation of a                    * * A360....
C * *          graphical display program for the saturated-               * * A370....
C * *          unsaturated transport (SUTRA) finite-element               * * A380....
C * *          model, U.S. Geological Survey Water-Resources              * * A390....
C * *          Investigations Report 87-4245.                             * * A400....
C * *                                                                     * * A410....
C * *                                                                     * * A420....
C * *       Program statements are individually numbered by               * * A430....
C * *       subroutine. Subroutines are labeled as follows:               * * A440....
C * *                                                                     * * A450....
C * *         A- V1086D          H- OLDSET          O- KONTUR             * * A460....
C * *         B- SUTRAP          I- SVESET          P- GRIDR              * * A470....
C * *         C- NEWSET          J- EDIT            Q- VECPLT             * * A480....
C * *         D- ASET            K- PLOT            R- MESHP              * * A490....
C * *         E- CSET            L- READ5           S- SKIP               * * A500....
C * *         F- MSET            M- READ6           T- QCHECK             * * A510....
C * *         G- VSET            N- OUTDEV          U- NCHECK             * * A520....
C * *                                                                     * * A530....
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * A540....
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * A550....
```

```
C                                                                       A560....
      DOUBLE PRECISION DPV                                              A570....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                                 A580....
      CHARACTER*6 SUTRA                                                 A590....
      CHARACTER*60 LXNAME,LYNAME                                        A600....
      CHARACTER*40 SUTRA5,SUTRA6                                        A610....
      COMMON /LGEV/ GV1,GV2                                             A620....
      COMMON /LGEMV/ IMV,IMG                                            A630....
      COMMON /DPV/ DPV                                                  A640....
      COMMON /EXT/ IQUIT                                                A650....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                   A660....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,              A670....
     1             YMIN,YINT,YMAX,                                      A680....
     2             IPLOT,NPLOT,IREAD,                                   A690....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                  A700....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                   A710....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                   A720....
     2                 ZINCR,UBASE,UMULT                                A730....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP           A740....
      COMMON /MESH/ ISIDE,NCOUNT                                        A750....
C                                                                       A760....
C-----------------------------------------------------------------------A770....
C|    Five arrays must be dimensioned based on the size of the         |A780....
C|    finite-element mesh used in the SUTRA simulation and the         |A790....
C|    size of the contour gridding matrix, as follows:                 |A800....
C|                                                                     |A810....
C---> DIMENSION DPV(DPVDIM), IMV(IMVDIM)                              |A820....
C|                                                                     |A830....
C|               DPVDIM >=  (3 * NN) + (3 * NE)                        |A840....
C|               IMVDIM >=   5 * NE                                   |A850....
C|      where:                                                         |A860....
C|         NN = number of nodes in finite element mesh                 |A870....
C|         NE = number of elements in finite element mesh              |A880....
C|                                                                     |A890....
C---> DIMENSION GV1(IXDIM*IYDIM), GV2(IXDIM*IYDIM), IMG(IXDIM*IYDIM)  |A900....
C|                                                                     |A910....
C|      where:                                                         |A920....
C|         IXDIM and IYDIM are the X & Y dimensions of the largest     |A930....
C|         gridding matrix to be generated for contour plots           |A940....
C|                                                                     |A950....
C|                                                                     |A960....
C|    The arrays to be dimensioned are just below.                     |A970....
C|                                                                     |A980....
C|---------------------------------------------------------------------A990....
      DIMENSION DPV(30000),IMV(30000)                                   A1000...
      DIMENSION GV1(10000),GV2(10000),IMG(10000)                        A1010...
C|-------------------------------------------------------------------|A1020...
C                                                                       A1030...
   10 IPLOT=0                                                           A1040...
      ISTAT=0                                                           A1050...
      IREAD=0                                                           A1060...
      ITYPE=0                                                           A1070...
      IMOD=0                                                            A1080...
C                                                                       A1090...
      WRITE (1,11)                                                      A1100...
```

Program listing -- continued

```
   11 FORMAT(/10X,'=================================================' A1110...
     1       /10X,'            S U T R A - P L O T '               A1120...
     2       /10X,'      I N T E R A C T I V E   G R A P H I C S'   A1130...
     3       /10X,'=================================================')A1140...
C                                                                    A1150...
   12 WRITE (1,15)                                                   A1160...
      READ (1,30) SUTRA5                                             A1170...
      IF (SUTRA5.EQ.'A'.OR.SUTRA5.EQ.'a') GOTO 800                   A1180...
      IF (SUTRA5.EQ.'') GOTO 12                                      A1190...
   15 FORMAT (/10X,'Enter pathname of SUTRA INPUT LIST file'         A1200...
     1        /10X,'     (enter <A> to abort program)'               A1210...
     2        /10X,'=======================================')        A1220...
C.....Open and read SUTRA input data file for NN and NE              A1230...
      OPEN (UNIT=75,FILE=SUTRA5,STATUS='OLD',ERR=17,IOSTAT=ISTAT)    A1240...
      NPLOT=0                                                        A1250...
   17 IF (ISTAT.NE.0) THEN                                           A1260...
         WRITE (1,20) SUTRA5                                         A1270...
         GOTO 12                                                     A1280...
      END IF                                                         A1290...
   20 FORMAT (/10X,'************************************************' A1300...
     1        /10X,'     ERROR IN OPENING FILE => ',A40,             A1310...
     2        /10x,'  This file may already be open or may not exist' A1320...
     3        /10X,'************************************************') A1330...
   30 FORMAT (A40)                                                   A1340...
      READ (75,33) SUTRA                                             A1350...
      IF (SUTRA.NE.'SUTRA') THEN                                     A1360...
         WRITE (1,35) SUTRA5                                         A1370...
         CLOSE (75)                                                  A1380...
         GOTO 12                                                     A1390...
      END IF                                                         A1400...
   33 FORMAT (A6)                                                    A1410...
   35 FORMAT (/10X,'************************************************' A1420...
     1        /10X,'     ERROR IN READING FILE => ',A40,             A1430...
     2        /10X,'   This file is a modified SUTRA input dataset'  A1440...
     3        /10X,'************************************************') A1450...
      CALL SKIP(75)                                                  A1460...
      CALL SKIP(75)                                                  A1470...
      READ (75,50) NN,NE                                             A1480...
   50 FORMAT(2I5)                                                    A1490...
      REWIND(75)                                                     A1500...
C                                                                    A1510...
C.....Set up pointers for vectors and matrices                       A1520...
C                                                                    A1530...
      NDP1=1                                                         A1540...
      NDP2=NDP1+NN                                                   A1550...
      NDP3=NDP2+NN                                                   A1560...
      NDP4=NDP3+NN                                                   A1570...
      NDP5=NDP4+NE                                                   A1580...
      NDP6=NDP5+NE                                                   A1590...
      IP1=1                                                          A1600...
      IP2=IP1+NE                                                     A1610...
C                                                                    A1620...
C.....Pass pointers to main control routine, SUTRAP                  A1630...
      CALL SUTRAP (DPV(NDP1),DPV(NDP2),DPV(NDP3),                    A1640...
     1             DPV(NDP4),DPV(NDP5),DPV(NDP6),                    A1650...
```

Program listing -- continued

```
     2             GV1(1),GV2(1),                                          A1660...
     3             IMV(IP1),IMV(IP2),IMG(1))                               A1670...
C                                                                          A1680...
      IF (IQUIT.EQ.1) GOTO 800                                             A1690...
C.....Else loop to beginning of program to read a new input data file      A1700...
      GOTO 10                                                              A1710...
C                                                                          A1720...
C.....Close all files and exit program gracefully                          A1730...
  800 CLOSE(70)                                                            A1740...
      CLOSE(71)                                                            A1750...
      CLOSE(72)                                                            A1760...
      CLOSE(73)                                                            A1770...
      CLOSE(74)                                                            A1780...
      CLOSE(75)                                                            A1790...
  999 STOP                                                                 A1800...
      END                                                                  A1810...
```

Program listing -- continued

```
C     ***           S U B R O U T I N E   S U T R A P                  B10.....
C     ***                      Version 1086S                           B20.....
C     *** Purpose:                                                     B30.....
C     ***    Main control routine for all plotting and file reading.   B40.....
C     ***    Program is menu driven from this routine.  All plotting   B50.....
C     ***    information is passed to Subroutine PLOT.                 B60.....
C                                                                      B70.....
      SUBROUTINE SUTRAP(X,Y,U,XYMAX,VMAG,VANG,                         B80.....
     1                  UGRID,UMAT,                                    B90.....
     2                  IXY,IN,LNUM)                                   B100....
      DOUBLE PRECISION X,Y,U,XYMAX,VMAG,VANG                           B110....
      CHARACTER REPLY                                                  B120....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                                B130....
      CHARACTER*60 LXNAME,LYNAME                                       B140....
      CHARACTER*40 SUTRA6                                              B150....
      CHARACTER*6 LINE(5)                                              B160....
      CHARACTER*8 LABEL(2)                                             B170....
      COMMON /EXT/ IQUIT                                               B180....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                  B190....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,             B200....
     1             YMIN,YINT,YMAX,                                     B210....
     2             IPLOT,NPLOT,IREAD,                                  B220....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                 B230....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                  B240....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                  B250....
     2                 ZINCR,UBASE,UMULT                               B260....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP          B270....
      COMMON /MESH/ ISIDE,NCOUNT                                       B280....
      DIMENSION X(NN),Y(NN),U(NN)                                      B290....
      DIMENSION VMAG(NE),VANG(NE),XYMAX(NE)                            B300....
      DIMENSION IN(NE,4),IXY(NE),LNUM(1),NODEP(500)                    B310....
      DIMENSION UMAT(1),UGRID(1)                                       B320....
C                                                                      B330....
      IMOD=0                                                           B340....
      ISAVE=0                                                          B350....
      IOLD=0                                                           B360....
      NCOUNT=1                                                         B370....
      NODEP(1)=1                                                       B380....
C                                                                      B390....
C.....Read input data file for node coordinates and incidence list     B400....
      CALL READ5(X,Y,IN)                                               B410....
  100 NPLOT=0                                                          B420....
C                                                                      B430....
C.....Write Main menu to screen                                        B440....
      WRITE (1,105)                                                    B450....
      WRITE (1,110)                                                    B460....
      CALL NCHECK (7,IOPTN,ISTAT)                                      B470....
      IF (ISTAT.NE.0) GOTO 100                                         B480....
  105 FORMAT(/10X,'==================================================' B490....
     1       /10X,'           S U T R A-P L O T '                     B500....
     2       /10X,'     I N T E R A C T I V E   G R A P H I C S'      B510....
     3       /10X,'==================================================')B520....
  110 FORMAT(/10X,'--------------------------------------------------' B530....
     1       /10X,'**********      M A I N   M E N U      **********' B540....
     2       /10X,'--------------------------------------------------' B550....
```

Program listing -- continued

```
     3       /10X,'           Select graphics option:'                    B560....
     4       /10X,'        1) Create a new plot set-up'                   B570....
     5       /10X,'        2) Read in existing set-up file'               B580....
     6       /10X,'        3) Modify current set-up'                      B590....
     7       /10X,'        4) Save new or modified set-up'                B600....
     8       /10X,'        5) Re-start with new INPUT DATA'               B610....
     9       /10X,'        6) Read new SUTRA OUTPUT'                      B620....
     A       /10X,'        7) PLOT'                                       B630....
     B       /10X,'           or (X) Exit program'                        B640....
     C       /10X,'================================================')B650....
C                                                                         B660....
      IF (IOPTN .EQ. 0) GOTO 100                                          B670....
C                                                                         B680....
      IF (IOPTN .EQ. 99) THEN                                             B690....
         WRITE (1,120)                                                    B700....
         CALL QCHECK(IQUIT,ISTAT)                                         B710....
         IF (IQUIT.EQ.1) GOTO 800                                         B720....
         GOTO 100                                                         B730....
      END IF                                                              B740....
  120 FORMAT (/10X,'************************************************' B750....
     1        /10X,'<<<       E X I T I N G    P R O G R A M      >>>' B760....
     2        /10X,'<<< NEW/MODIFIED SETUPS NOT SAVED WILL BE LOST >>>' B770....
     3        /10X,'<<<   Are you sure you want to quit?? (Y/N?)   >>>' B780....
     4        /10X,'************************************************')B790....
C                                                                         B800....
      IF (IOPTN .EQ. 7) IPLOT=1                                           B810....
C                                                                         B820....
      IF (IOPTN .EQ. 6) THEN                                              B830....
         IPLOT=1                                                          B840....
         IREAD=0                                                          B850....
         GOTO 200                                                         B860....
      END IF                                                              B870....
C                                                                         B880....
      IF (IOPTN .EQ. 5) THEN                                              B890....
         IQUIT=0                                                          B900....
         GOTO 800                                                         B910....
      END IF                                                              B920....
C                                                                         B930....
      IF (IOPTN .EQ. 4) THEN                                              B940....
         IF (IMOD.EQ.0) THEN                                              B950....
            WRITE (1,130)                                                 B960....
            READ (1,140) REPLY                                            B970....
            GOTO 100                                                      B980....
         END IF                                                           B990....
         ISAVE=1                                                          B1000...
         CALL SVESET(LNUM,NODEP)                                          B1010...
         GOTO 100                                                         B1020...
      END IF                                                              B1030...
C                                                                         B1040...
      IF (IOPTN .EQ. 3) THEN                                              B1050...
         IF (IMOD.EQ.0) THEN                                              B1060...
            WRITE (1,130)                                                 B1070...
            READ (1,140) REPLY                                            B1080...
            GOTO 100                                                      B1090...
         END IF                                                           B1100...
```

Program listing -- continued

```
         CALL EDIT                                                          B1110...
         GOTO 100                                                           B1120...
      END IF                                                                B1130...
  130 FORMAT (/10X,'****    A setup file has to be CREATED    ****'        B1140...
     1        /10X,'****     or READ-IN BEFORE PLOTTING or    ****'        B1150...
     2        /10X,'****   using the MODIFY or SAVE options   ****'        B1160...
     3        /10X,'****      PRESS <RETURN> TO CONTINUE      ****')       B1170...
  140 FORMAT (A)                                                            B1180...
C                                                                           B1190...
      IF (IOPTN .EQ. 1) THEN                                                B1200...
         IF (IMOD.EQ.1) THEN                                                B1210...
            WRITE (1,160)                                                   B1220...
            CALL QCHECK(ISAVE,ISTAT)                                        B1230...
            IF (ISAVE.EQ.1) CALL SVESET(LNUM,NODEP)                         B1240...
         END IF                                                             B1250...
         IMOD=1                                                             B1260...
         ITYPE=0                                                            B1270...
         CALL NEWSET                                                        B1280...
         WRITE (1,150)                                                      B1290...
         CALL QCHECK(IPLOT,ISTAT)                                           B1300...
         IF (IPLOT.EQ.1) GOTO 200                                           B1310...
      END IF                                                                B1320...
  150 FORMAT (/10X,'Plot the new set-up (Y/N?)'                             B1330...
     1        /10X,'--------------------------')                            B1340...
C                                                                           B1350...
      IF (IOPTN .EQ. 2) THEN                                                B1360...
         IF (IMOD.EQ.1) THEN                                                B1370...
            WRITE (1,160)                                                   B1380...
            CALL QCHECK(ISAVE,ISTAT)                                        B1390...
            IF (ISAVE.EQ.1) CALL SVESET(LNUM,NODEP)                         B1400...
         END IF                                                             B1410...
         IMOD=1                                                             B1420...
         ITYPE=0                                                            B1430...
         IOLD=0                                                             B1440...
         CALL OLDSET(LNUM,NODEP,IOLD)                                       B1450...
         GOTO 100                                                           B1460...
      END IF                                                                B1470...
  160 FORMAT (/10X,'<<<  Reading in or creating a new setup will  >>>'      B1480...
     1        /10x,'<<<    cause the current setup to be lost     >>>'      B1490...
     2        /10x,'<<<      SAVE THE CURRENT SET-UP? (Y/N?)      >>>')     B1500...
C                                                                           B1510...
      IF (IPLOT.EQ.0) THEN                                                  B1520...
         CALL EDIT                                                          B1530...
         GOTO 100                                                           B1540...
      END IF                                                                B1550...
C                                                                           B1560...
      IF (IPLOT.EQ.1) GOTO 200                                              B1570...
      GOTO 100                                                              B1580...
C                                                                           B1590...
  200 IF (IMOD.EQ.0) THEN                                                   B1600...
         WRITE (1,130)                                                      B1610...
         READ (1,140) REPLY                                                 B1620...
         GOTO 100                                                           B1630...
      END IF                                                                B1640...
C                                                                           B1650...
```

Program listing -- continued

```
      IF (IPLOT.EQ.0) GOTO 100                                  B1660...
         CALL PLOT(X,Y,U,XYMAX,VMAG,VANG,                       B1670...
     1             UGRID,UMAT,                                  B1680...
     2             IXY,IN,LNUM,NODEP)                           B1690...
      GOTO 100                                                  B1700...
C                                                               B1710...
  800 RETURN                                                    B1720...
      END                                                       B1730...
```

Program listing -- continued

```
         CALL VSET                                                  C560....
         GOTO 200                                                   C570....
C.....Meshplot parameters                                           C580....
      ELSE IF (IOPTN .EQ. 3) THEN                                   C590....
         PLOTYPE = 'MESH'                                           C600....
         CALL MSET                                                  C610....
         GOTO 200                                                   C620....
      END IF                                                        C630....
C                                                                   C640....
  200 RETURN                                                        C650....
      END                                                           C660....
```

Program listing -- continued

```
C     ***          S U B R O U T I N E    N E W S E T                  C10.....
C     ***                    Version 1086S                              C20.....
C     *** Purpose                                                       C30.....
C     ***    Controls the creation of new setup parameter files         C40.....
C     ***    according to the type of plot requested                    C50.....
C                                                                       C60.....
      SUBROUTINE NEWSET                                                 C70.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                                 C80.....
      CHARACTER*60 LXNAME,LYNAME                                        C90.....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                   C100....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,              C110....
     1             YMIN,YINT,YMAX,                                      C120....
     2             IPLOT,NPLOT,IREAD,                                   C130....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                  C140....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                   C150....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                   C160....
     2                 ZINCR,UBASE,UMULT                                C170....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP           C180....
      COMMON /MESH/ ISIDE,NCOUNT                                        C190....
C                                                                       C200....
      IPLOT=0                                                           C210....
      ISTAT=0                                                           C220....
      IOLD=0                                                            C230....
C                                                                       C240....
  100 WRITE (1,110)                                                     C250....
  110 FORMAT (//'** C R E A T E   N E W   S E T - U P **'               C260....
     1         /'       Select type of plot:'                          C270....
     2         /'         1) Contour'                                  C280....
     3         /'         2) Velocity vector'                          C290....
     4         /'         3) Meshplot'                                 C300....
     5         /'       Enter 1,2, or 3')                              C310....
      CALL NCHECK (3,IOPTN,ISTAT)                                       C320....
      IF (ISTAT.NE.0) GOTO 100                                          C330....
  115 WRITE(1,120)                                                      C340....
  120 FORMAT (/10X,'  PAGE and AXIS set-up'                             C350....
     1        /10x,'     1) Read-in page set-up from existing file'     C360....
     2        /10X,'     2) Use information in current set-up'         C370....
     3        /10X,'     3) Create new page set-up'                    C380....
     4        /10X,'  Enter 1,2, or 3')                               C390....
      CALL NCHECK (3,IOLD,ISTAT)                                        C400....
      IF (IOLD.NE.3) THEN                                               C410....
         IF (IOLD.EQ.1) CALL OLDSET (L,N,IOLD)                          C420....
         IF (IOLD.EQ.99) GOTO 115                                       C430....
         GOTO 150                                                       C440....
      END IF                                                            C450....
C.....Call input routine for common plot parameters                     C460....
      CALL ASET                                                         C470....
C.....Contour parameters                                                C480....
  150 IF (IOPTN .EQ. 1) THEN                                            C490....
         PLOTYPE = 'CONT'                                               C500....
         CALL CSET                                                      C510....
         GOTO 200                                                       C520....
C.....Vectorplot parameters                                             C530....
      ELSE IF (IOPTN .EQ. 2) THEN                                       C540....
         PLOTYPE = 'VECT'                                               C550....
```

Program listing -- continued

```
C    ***              S U B R O U T I N E   A S E T                    D10.....
C    ***                       Version 1086S                           D20.....
C    *** Purpose:                                                      D30.....
C    ***    Prompts for and saves plotting parameters common          D40.....
C    ***    common to all plots.                                      D50.....
C                                                                      D60.....
      SUBROUTINE ASET                                                  D70.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                                D80.....
      CHARACTER*60 LXNAME,LYNAME,TNAME                                 D90.....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                  D100....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,             D110....
     1             YMIN,YINT,YMAX,                                     D120....
     2             IPLOT,NPLOT,IREAD,                                  D130....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                 D140....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                  D150....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                  D160....
     2                 ZINCR,UBASE,UMULT                               D170....
      COMMON /MESH/ ISIDE,NCOUNT                                       D180....
C                                                                      D190....
C.....I/O error status flag                                           D200....
      ISTAT=0                                                          D210....
C                                                                      D220....
  105 IF (ISTAT.NE.0) WRITE (1,370)                                    D230....
      WRITE (1,110)                                                    D240....
  110 FORMAT (/'Enter label for x-axis'                                D250....
     1        /' (C/R = no label)')                                    D260....
      READ (1,125,ERR=105,IOSTAT=ISTAT) TNAME                          D270....
      LXNAME=TNAME                                                     D280....
C                                                                      D290....
  115 IF (ISTAT.NE.0) WRITE (1,370)                                    D300....
      WRITE (1,120)                                                    D310....
  120 FORMAT (/'Enter label for y-axis'                                D320....
     1        /' (C/R = no label)')                                    D330....
      READ (1,125,ERR=115,IOSTAT=ISTAT) TNAME                          D340....
      LYNAME=TNAME                                                     D350....
  125 FORMAT (A)                                                       D360....
C                                                                      D370....
  200 IF (ISTAT.NE.0) WRITE (1,370)                                    D380....
      WRITE (1,210)                                                    D390....
  210 FORMAT (/'Enter plotting page size in inches (X,Y)')              D400....
      READ (1,*,ERR=200,IOSTAT=ISTAT) PAGEX,PAGEY                      D410....
C                                                                      D420....
  215 IF (ISTAT.NE.0) WRITE (1,370)                                    D430....
      XRANGE=XMAX-XMIN                                                 D440....
      YRANGE=YMAX-YMIN                                                 D450....
      IF (PAGEY/YRANGE.LT.PAGEX/XRANGE) THEN                           D460....
         YAXIS=PAGEY-2.0                                               D470....
         XAXIS=XRANGE/YRANGE*YAXIS                                     D480....
      ELSE                                                             D490....
         XAXIS=PAGEX-2.0                                               D500....
         YAXIS=YRANGE/XRANGE*XAXIS                                     D510....
      END IF                                                           D520....
      WRITE (1,220) XRANGE,XAXIS,YRANGE,YAXIS                          D530....
  220 FORMAT (/10X,'Plotted axis lengths will be automatically'        D540....
     1        /10x,' set proportional to the coordinate range'         D550....
```

Program listing -- continued

```
     2        /10x,'        in the input data list'                    D560....
     3        /10x,' X-coordinate range = ',F10.2,' (model units)'     D570....
     4        /10x,' X-axis will be set = ',F10.2,' inches'            D580....
     5       //10x,' Y-coordinate range = ',F10.2,' (model units)'     D590....
     6        /10x,' Y-axis will be set = ',F10.2,' inches'            D600....
     7        /10x,'Do you want to change these settings? (Y/N?)')     D610....
      CALL QCHECK (ISCALE,ISTAT)                                       D620....
      IF (ISCALE.EQ.0) GOTO 300                                        D630....
  280 IF (ISTAT.NE.0) WRITE (1,370)                                    D640....
      WRITE (1,290)                                                    D650....
  290 FORMAT (/'Enter axis lengths in inches (X,Y)')                   D660....
      READ (1,*,ERR=280,IOSTAT=ISTAT) XAXIS,YAXIS                      D670....
C                                                                      D680....
  300 IF (ISTAT.NE.0) WRITE (1,370)                                    D690....
      WRITE (1,305) XMIN,XMAX                                          D700....
  305 FORMAT (/10X,'Minimum X-coordinate = ',F10.3,                    D710....
     1        /10X,'Maximum X-coordinate = ',F10.3)                   D720....
      WRITE (1,310)                                                    D730....
  310 FORMAT (/'Enter increment for X-axis ticks in model units')      D740....
      READ (1,*,ERR=300,IOSTAT=ISTAT) XINT                             D750....
  320 IF (ISTAT.NE.0) WRITE (1,370)                                    D760....
      WRITE (1,325) YMIN,YMAX                                          D770....
  325 FORMAT (/10X,'Minimum Y-coordinate = ',F10.3,                    D780....
     1        /10X,'Maximum Y-coordinate = ',F10.3)                   D790....
      WRITE (1,330)                                                    D800....
  330 FORMAT (/'Enter increment for Y-axis ticks in model units')      D810....
      READ (1,*,ERR=320,IOSTAT=ISTAT) YINT                             D820....
C                                                                      D830....
  370 FORMAT (/'********  I/O ERROR : RE-ENTER  ********')             D840....
      RETURN                                                           D850....
      END                                                              D860....
```

Program listing -- continued

```
C    ***           S U B R O U T I N E   C S E T                    E10.....
C    ***                    Version 1086S                           E20.....
C    *** Purpose:                                                   E30.....
C    ***    Prompts for and saves CONTOUR plot parameters           E40.....
C                                                                   E50.....
      SUBROUTINE CSET                                              E60.....
      CHARACTER REPLY                                              E70.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                            E80.....
      CHARACTER*60 LXNAME,LYNAME                                   E90.....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                              E100....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,         E110....
     1             YMIN,YINT,YMAX,                                 E120....
     2             IPLOT,NPLOT,IREAD,                              E130....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME             E140....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,              E150....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,              E160....
     2                 ZINCR,UBASE,UMULT                           E170....
C                                                                  E180....
      ISTAT=0                                                      E190....
      NUMDIR=0                                                     E200....
      WRITE (1,100)                                                E210....
  100 FORMAT (/10X,'     CONTOUR Plot set-up'                      E220....
     1        /10x,'-----------------------------')                E230....
  110 WRITE (1,120)                                                E240....
      CALL NCHECK (4,IOPTN,ISTAT)                                  E250....
      IF (ISTAT.NE.0) GOTO 110                                     E260....
      IF (IOPTN .EQ. 1) THEN                                       E270....
         CONTYPE = 'CONC'                                          E280....
         CONTX = 'C  O'                                            E290....
      ELSE IF (IOPTN .EQ. 2) THEN                                  E300....
         CONTYPE = 'TEMP'                                          E310....
         CONTX = 'T  E'                                            E320....
      ELSE IF (IOPTN .EQ. 3) THEN                                  E330....
         CONTYPE = 'PRES'                                          E340....
         CONTX = 'P  R'                                            E350....
      ELSE IF (IOPTN .EQ. 4) THEN                                  E360....
         CONTYPE = 'SATU'                                          E370....
         CONTX = 'S  A'                                            E380....
      END IF                                                       E390....
C                                                                  E400....
  120 FORMAT (/10X,'Select type of contour plot:'                  E410....
     1        /10X,'  1) Concentration'                           E420....
     2        /10X,'  2) Temperature'                            E430....
     3        /10X,'  3) Pressure'                               E440....
     4        /10X,'  4) Saturation'                            E450....
     5        /10X,'Enter 1,2,3, or 4')                         E460....
C                                                                  E470....
  130 IF (ISTAT.NE.0) WRITE (1,999)                                E480....
      WRITE (1,150)                                                E490....
  150 FORMAT (/10X,'Select method for gridding data:'              E500....
     1        /10X,'  1) DISSPLA grid routine'                    E510....
     2        /10X,'  2) Finite-element grid program'            E520....
     3        /10X,'  3) No gridding - (regular, rectangular'    E530....
     4        /10X,'     finite-element meshes only)'            E540....
     5        /10X,'Enter 1,2 or 3')                            E550....
```

Program listing -- continued

```
C                                                                       E560....
      CALL NCHECK(3,IVALUE,ISTAT)                                       E570....
      IF (IVALUE.EQ.1) IGRID=1                                          E580....
      WRITE (1,170)                                                     E590....
  170 FORMAT (/'Enter dimensions of gridding matrix (X,Y)'              E600....
     1        /' (x=number of columns; y=number of rows)')              E610....
      READ (1,*,ERR=130,IOSTAT=ISTAT) IXDIM,IYDIM                       E620....
      IF (IVALUE.EQ.2) IGRID=2                                          E630....
      IF (IVALUE.EQ.3) THEN                                             E640....
  185    WRITE (1,198) IXDIM,IYDIM,NUMDIR                               E650....
         CALL NCHECK(5,IVAR,ISTAT)                                      E660....
         IF (IVAR.GT.3) THEN                                            E670....
           IF (IVAR.EQ.5) GOTO 130                                      E680....
           IF (IVAR.EQ.4) IGRID=3                                       E690....
           GOTO  200                                                    E700....
         END IF                                                         E710....
         WRITE (1,500)                                                  E720....
         READ (1,520,ERR=195) IVALUE                                    E730....
         GOTO (191,192,193,200) IVAR                                    E740....
  191    IXDIM=IVALUE                                                   E750....
         GOTO 185                                                       E760....
  192    IYDIM=IVALUE                                                   E770....
         GOTO 185                                                       E780....
  193    IF (IVALUE.GT.1) GOTO 195                                      E790....
         NUMDIR=IVALUE                                                  E800....
         GOTO 185                                                       E810....
  195    WRITE (1,560)                                                  E820....
         READ (1,550) REPLY                                             E830....
         GOTO 185                                                       E840....
      END IF                                                            E850....
C                                                                       E860....
  198 FORMAT (/10X,'*****************   CAUTION   *********************'E870....
     1        /10X,'         <<NO GRIDDING>> OPTION SELECTED'           E880....
     2        /10X,'************************************************'E890....
     3        /10X,'   Data may be contoured without gridding ONLY if' E900....
     4        /10X,' the finite-element mesh is RECTANGULAR and REGULAR'E910....
     5        /10X,'  The number of rows and columns for the grid must' E920....
     6        /10x,'   be set equal to the number of rows and columns' E930....
     7        /10x,'            in the finite-element mesh'           E940....
     8        /10X,'       ** Mesh numbering flag MUST be set **'     E950....
     9        /10X,'================================================'E960....
     A        /10X,'  Select one:'                                     E970....
     B        /10X,'    Change: '                                      E980....
     C        /10X,'  1) X-grid-dimension (columns): IXDIM=',I3,      E990....
     D        /10X,'  2) Y-grid-dimension (rows):    IYDIM=',I3,     E1000...
     E        /10X,'  3) Mesh numbering flag:        NUMDIR=',I2,    E1010...
     F        /10X,'     0=mesh numbered along rows (X-direction)'    E1020...
     G        /10X,'     1=mesh numbered along columns (Y-direction)' E1030...
     H       //10X,'  4)Use   <<No gridding>> option'                  E1040...
     I        /10X,'  5)ABORT <<No gridding>> option')                 E1050...
                                                                       E1060...
  200 IF (ISTAT.NE.0) WRITE (1,999)                                    E1070...
      WRITE (1,210)                                                    E1080...
  210 FORMAT (/'Do you want to re-scale the data prior to contouring?' E1090...
     1        /'  (Y/N?) ')                                           E1100...
```

Program listing -- continued

```
      CALL QCHECK (ISCAL,ISTAT)                                          E1110...
      IF (ISCAL.EQ.1) THEN                                               E1120...
         WRITE (1,220)                                                   E1130...
  220    FORMAT (/'     Enter scaling factors (UBASE,UMULT)'              E1140...
     1           /'   [Plotted data = (true data/UBASE)* UMULT]')       E1150...
         READ (1,*,ERR=200,IOSTAT=ISTAT) UBASE,UMULT                     E1160...
      END IF                                                             E1170...
C                                                                        E1180...
      WRITE (1,230)                                                      E1190...
  230 FORMAT (/'Do you want DISSPLA to select contour intervals (Y/N?)')E1200...
      CALL QCHECK(IZIN,ISTAT)                                            E1210...
      IF (IZIN.EQ.1) GOTO 250                                            E1220...
      WRITE (1,240)                                                      E1230...
      READ (1,*,ERR=200,IOSTAT=ISTAT) ZINCR                              E1240...
  240 FORMAT (/'  Enter contour interval in model units')                E1250...
C                                                                        E1260...
  250 WRITE (1,260)                                                      E1270...
  260 FORMAT (/'Default line characteristics are:'                       E1280...
     1        /'  - solid lines'                                         E1290...
     2        /'  - labels'                                             E1300...
     3        /'  - thickness .01 inch'                                 E1310...
     4        /'Change defaults (Y/N?)')                                E1320...
      CALL QCHECK(IDEF,ISTAT)                                            E1330...
      IF (IDEF.EQ.1) THEN                                                E1340...
  270    WRITE (1,280)                                                   E1350...
  280    FORMAT (/'Line types:'                                          E1360...
     1           /'   1) Dot'                                           E1370...
     2           /'   2) Dash'                                          E1380...
     3           /'   3) Chain dotted'                                  E1390...
     4           /'   4) Chain dashed'                                  E1400...
     5           /'   5) Solid'                                         E1410...
     6           /'Enter 1,2,3,4, or 5')                               E1420...
         CALL NCHECK (5,MODE,ISTAT)                                      E1430...
         IF (ISTAT.NE.0) GOTO 270                                        E1440...
C                                                                        E1450...
  290    WRITE (1,300)                                                   E1460...
  300    FORMAT(/'Labeling options:'                                     E1470...
     1          /'  1) Label the lines'                                 E1480...
     2          /'  2) No labels'                                       E1490...
     3          /'Enter 1 or 2')                                       E1500...
         CALL NCHECK (2,LBLFLG,ISTAT)                                    E1510...
         IF (ISTAT.NE.0) GOTO 290                                        E1520...
  310    IF (ISTAT.NE.0) WRITE (1,999)                                   E1530...
C                                                                        E1540...
         WRITE (1,320)                                                   E1550...
  320    FORMAT (/'Enter line thickness in INTEGER multiples'            E1560...
     1           /'  of 0.01 inch ( eg, 5 = .05 inch)')                 E1570...
         READ (1,*,ERR=310,IOSTAT=ISTAT) ITHICK                          E1580...
         ELSE                                                            E1590...
           MODE=5                                                        E1600...
           LBLFLG=1                                                      E1610...
           ITHICK=1                                                      E1620...
      END IF                                                             E1630...
C                                                                        E1640...
  500 FORMAT (/10X,'    Enter value'                                     E1650...
```

Program listing -- continued

```
   1        /10X,'    -----------')                                    E1660...
 520 FORMAT (I5)                                                       E1670...
 550 FORMAT (A)                                                        E1680...
 560 FORMAT (/10X,'**************  INPUT ERROR  ***************'       E1690...
   1        /10X,'*************  OR INVALID ENTRY  *************'     E1700...
   2        /10X,'*******  Press <RETURN> to continue  *******')      E1710...
 999 FORMAT (/10X,'********  I/O ERROR : RE-ENTER  ********')          E1720...
     RETURN                                                            E1730...
     END                                                               E1740...
```

Program listing -- continued

```
C     ***           S U B R O U T I N E   M S E T                    F10.....
C     ***                Version 1086S                               F20.....
C     *** Purpose:                                                   F30.....
C     ***    Prompts for and saves plotting parameters for           F40.....
C     ***    for mesh plots.                                         F50.....
C                                                                    F60.....
      SUBROUTINE MSET                                                F70.....
      COMMON /MESH/ ISIDE,NCOUNT                                     F80.....
C                                                                    F90.....
      ISTAT =0                                                       F100....
      WRITE( 1,100)                                                  F110....
      CALL NCHECK(3,ISIDE,ISTAT)                                     F120....
C                                                                    F130....
  100 FORMAT (/10X,'              MESHPLOT set-up'                   F140....
     1        /10x,'-----------------------------------------------'  F150....
     2        /10x,'    Select one:'                                 F160....
     3        /10x,'1) Plot ALL sides of ALL elements'               F170....
     4        /10x,'2) Plot WITHOUT duplicating sides'               F180....
     5        /10X,'3) Plot PERIMETER of mesh only'                  F190....
     6        /10x,'-----------------------------------------------') F200....
C                                                                    F210....
      RETURN                                                         F220....
      END                                                            F230....
```

Program listing -- continued

```
C     ***          S U B R O U T I N E   V S E T                    G10.....
C     ***                    Version 1086S                          G20.....
C     *** Purpose:                                                  G30.....
C     ***    Prompts for and saves plotting parameters for          G40.....
C     ***    for vector plots.                                      G50.....
C     ***                                                           G60.....
C                                                                   G70.....
      SUBROUTINE VSET                                               G80.....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP       G90.....
C                                                                   G100....
      ISTAT=0                                                       G110....
      WRITE (1,110)                                                 G120....
  110 FORMAT (/10X,'            VECTORPLOT Setup'                   G130....
     1        /10X,'----------------------------------------')      G140....
  200 IF (ISTAT.NE.0) WRITE (1,500)                                 G150....
C                                                                   G160....
      WRITE (1,210)                                                 G170....
      READ (1,*,ERR=200) VPSCL                                      G180....
  210 FORMAT (/10X,'    Set maximum plotted vector LENGTH:'         G190....
     1       //10x,'   Vectors are scaled by selecting the'         G200....
     2        /10x,'   plotted length of the largest vector'       G210....
     3        /10x,'-> Enter plotted length for the'               G220....
     4        /10x,'   largest vector in inches')                  G230....
C                                                                   G240....
      WRITE (1,220)                                                 G250....
      CALL NCHECK(2,ILSCL,ISTAT)                                    G260....
  220 FORMAT (/10X,'Select type of vector length scaling:'          G270....
     1        /10X,'  1) Linear fraction of largest vector'        G280....
     2        /10X,'  2) Logrithmic fraction of largest vector')   G290....
C                                                                   G300....
      WRITE (1,230)                                                 G310....
      CALL QCHECK(IASCL,ISTAT)                                      G320....
  230 FORMAT (/10X,'Re-scale vector DIRECTION to conform to a '     G330....
     1        /10x,'distorted plot page?  (e.g., a cross-section'   G340....
     2        /10x,'with vertical exaggeration)'                    G350....
     3        /10x,'         (Y/N?)')                               G360....
C                                                                   G370....
  245 WRITE (1,250)                                                 G380....
      CALL QCHECK(IDEF,ISTAT)                                       G390....
  250 FORMAT (/10X,'Default vector type is:'                        G400....
     1        /10X,'   -Stick arrowhead, ->'                       G410....
     2        /10X,'   -Plotted arrowhead size = .15 inch'         G420....
     3        /10X,'Change defaults? (Y/N?)')                       G430....
C                                                                   G440....
      IF (IDEF.EQ.1) THEN                                           G450....
         IVEC=1001                                                  G460....
         WRITE (1,260)                                              G470....
         CALL NCHECK(3,ITYPE,ISTAT)                                 G480....
  255    WRITE (1,270)                                              G490....
         CALL NCHECK(6,ISIZE,ISTAT)                                 G500....
         IVEC=1001+(ISIZE*100)+((ITYPE-1)*10)                       G510....
      ELSE                                                          G520....
         IVEC=1221                                                  G530....
      END IF                                                        G540....
C                                                                   G550....
```

Program listing -- continued

```
  260 FORMAT (/10X,'Arrowhead types:'                                    G560....
     1        /10x,'  1) Solid'                                          G570....
     2        /10X,'  2) Empty'                                          G580....
     3        /10x,'  3) Stick'                                          G590....
     4        /10X,'Select 1,2, or 3')                                   G600....
C                                                                        G610....
  270 FORMAT (/10X,'Arrowhead size (inches):'                            G620....
     1        /10x,'  1) .075'                                          G630....
     2        /10x,'  2) .15'                                           G640....
     3        /10x,'  3) .225'                                          G650....
     4        /10x,'  4) .3'                                            G660....
     5        /10x,'  5) .375'                                          G670....
     6        /10x,'  6) .45'                                           G680....
     7        /10x,'Select one')                                        G690....
C                                                                        G700....
      WRITE (1,280)                                                      G710....
      CALL NCHECK(3,ITHIN,ISTAT)                                         G720....
      ISKIP=1                                                            G730....
      VLSCL=1.E-9                                                        G740....
      IF (ITHIN.EQ.2) THEN                                               G750....
  275    WRITE (1,285)                                                   G760....
         READ (1,*,ERR=275) ISKIP                                        G770....
      END IF                                                             G780....
      IF (ITHIN.EQ.3) THEN                                               G790....
  277    WRITE (1,290)                                                   G800....
         READ (1,*,ERR=277) VLSCL                                        G810....
      END IF                                                             G820....
  280 FORMAT (/10x,'Vector thinning options:'                             G830....
     1        /10x,'  1) No thinning-plot all vectors'                   G840....
     2        /10x,'  2) Plot every Nth vector'                         G850....
     3        /10x,'  3) Skip small vectors'                           G860....
     4        /10x,'Select 1,2, or 3')                                  G870....
C                                                                        G880....
  285 FORMAT (/10X,'Enter skip interval for vector thinning:'             G890....
     1        /10x,' (eg, 3= plot every third vector)')                 G900....
C                                                                        G910....
  290 FORMAT (/10X,'Enter a fractional length of largest vector:'         G920....
     1        /10x,' (eg, .01= Will NOT PLOT vectors less than'         G930....
     2        /10x,'       one-hundredth of the largest')               G940....
C                                                                        G950....
  500 FORMAT (/10X,'******  I/O ERROR : RE-ENTER  ******')               G960....
      RETURN                                                             G970....
      END                                                                G990....
```

Program listing -- continued

```
C     ***          S U B R O U T I N E   O L D S E T                  H10.....
C     ***                    Version 1086S                            H20.....
C     *** Purpose:                                                    H30.....
C     ***    Prompts for and reads existing set-up file               H40.....
C                                                                     H50.....
      SUBROUTINE OLDSET(LNUM,NODEP,IOLD)                              H60.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                               H70.....
      CHARACTER*60 LXNAME,LYNAME                                      H80.....
      CHARACTER*40 OLDFILE                                            H90.....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                 H100....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,            H110....
     1             YMIN,YINT,YMAX,                                    H120....
     2             IPLOT,NPLOT,IREAD,                                 H130....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                H140....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                 H150....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                 H160....
     2                 ZINCR,UBASE,UMULT                              H170....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP         H180....
      COMMON /MESH/ ISIDE,NCOUNT                                      H190....
      DIMENSION LNUM(1),NODEP(500)                                    H200....
C                                                                     H210....
   10 ISTAT=0                                                         H220....
      WRITE (1,20)                                                    H230....
      READ (1,25) OLDFILE                                             H240....
      IF (OLDFILE.EQ.'') GOTO 10                                      H250....
      IF (OLDFILE.EQ.'A'.OR.OLDFILE.EQ.'a') THEN                      H260....
         IOLD=99                                                      H270....
         RETURN                                                       H280....
      END IF                                                          H290....
      OPEN (UNIT=71,FILE=OLDFILE,STATUS='OLD',ERR=30,IOSTAT=ISTAT)    H300....
   20 FORMAT (//10X,'Enter pathname of PLOT SETUP file'               H310....
     1         /10X,' (enter <A> to abort this option)'               H320....
     2         /10X,'================================')              H330....
   25 FORMAT (A40)                                                    H340....
   30 IF (ISTAT.NE.0) THEN                                            H350....
         WRITE (1,35) OLDFILE                                         H360....
         GOTO 10                                                      H370....
      END IF                                                          H380....
C                                                                     H390....
   35 FORMAT (/10X,'*********************************************'    H400....
     1        /10X,'    ERROR IN OPENING FILE => ',A40,               H410....
     2        /10X,'*********************************************')   H420....
C                                                                     H430....
C.....Read parameters common to all plots                             H440....
      READ (71,400) PLOTYPE                                           H450....
      READ (71,405) LXNAME                                            H460....
      READ (71,405) LYNAME                                            H470....
      READ (71,410)       PAGEX,PAGEY                                 H480....
      READ (71,410)       XAXIS,YAXIS                                 H490....
      READ (71,410)       XINT,YINT                                   H500....
      READ (71,410)       XMIN,YMIN                                   H510....
      READ (71,410)       XMAX,YMAX                                   H520....
      CALL SKIP(71)                                                   H530....
      IF (IOLD.EQ.1) GOTO 450                                         H540....
C                                                                     H550....
```

Program listing -- continued

```
      IF (PLOTYPE.EQ.'MESH'.OR.PLOTYPE.EQ.'VECT') GOTO 100              H560....
C.....Read contour plot parameters                                      H570....
      READ (71,425) CONTYPE,CONTX                                       H580....
      READ (71,435) IXDIM,IYDIM,IDIR,NUMDIR                             H590....
      READ (71,430) IGRID,IZIN,ISCAL                                    H600....
      READ (71,430) MODE,LBLFLG,ITHICK                                  H610....
      READ (71,420) ZINCR,UBASE,UMULT                                   H620....
      IF (IGRID.EQ.2) THEN                                              H630....
C.....Read gridding data for F-E interpolator                           H640....
         READ(71,445,ERR=90,END=90) (LNUM(I),I=1,IXDIM*IYDIM)           H650....
         ITYPE=1                                                        H660....
      END IF                                                            H670....
      GOTO 450                                                          H680....
C                                                                       H690....
   90 ITYPE=0                                                           H700....
      GOTO 450                                                          H710....
  100 IF (PLOTYPE.EQ.'MESH') GOTO 200                                   H720....
C                                                                       H730....
C.....Read vector plot parameters                                       H740....
      READ (71,435) IVEC,ILSCL,IASCL,ISKIP                              H750....
      READ (71,440) VPSCL,VLSCL                                         H760....
      GOTO 450                                                          H770....
C                                                                       H780....
C.....Read mesh plot parameter                                          H790....
  200 READ (71,430) ISIDE                                               H800....
      IF (ISIDE.EQ.3) THEN                                              H810....
         READ (71,415) NCOUNT                                           H820....
         READ (71,445) (NODEP(I),I=1,NCOUNT)                            H830....
      END IF                                                            H840....
C                                                                       H850....
  400 FORMAT (A4)                                                       H860....
  405 FORMAT (A60)                                                      H870....
  410 FORMAT (10X,2F15.5)                                               H880....
  415 FORMAT (I5)                                                       H890....
  420 FORMAT (3F15.5)                                                   H900....
  425 FORMAT (A4,5X,A4)                                                 H910....
  430 FORMAT (3I10)                                                     H920....
  435 FORMAT (4I10)                                                     H930....
  440 FORMAT (F10.4,E10.2)                                              H940....
  445 FORMAT (16I5)                                                     H950....
  450 REWIND (71)                                                       H960....
      RETURN                                                            H970....
      END                                                               H980....
```

Program listing -- continued

```
C     ***        S U B R O U T I N E   S V E S E T                    I10.....
C     ***                  Version 1086S                              I20.....
C     *** Purpose:                                                    I30.....
C     ***    Writes new or modified set-up file to disk               I40.....
C                                                                     I50.....
      SUBROUTINE SVESET(LNUM,NODEP)                                   I60.....
      CHARACTER*40 NEWFILE                                            I70.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                               I80.....
      CHARACTER*60 LXNAME,LYNAME                                      I90.....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                 I100....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,            I110....
     1             YMIN,YINT,YMAX,                                    I120....
     2             IPLOT,NPLOT,IREAD,                                 I130....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                I140....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                 I150....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                 I160....
     2                 ZINCR,UBASE,UMULT                              I170....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP         I180....
      COMMON /MESH/ ISIDE,NCOUNT                                      I190....
      DIMENSION LNUM(IXDIM*IYDIM),NODEP(500)                          I200....
C                                                                     I210....
   10 IF (ISAVE.EQ.0) THEN                                            I220....
         WRITE (1,20)                                                 I230....
      ELSE                                                            I240....
         WRITE (1,22)                                                 I250....
      END IF                                                          I260....
      READ (1,25) NEWFILE                                             I270....
      IF (NEWFILE.EQ.'') GOTO 10                                      I280....
   20 FORMAT (//10X,'Enter filename to save NEW set-up'               I290....
     1         /10X,'================================')               I300....
   22 FORMAT (//10X,'Enter filename to save MODIFIED set-up'          I310....
     1         /10X,'========================================')       I320....
   25 FORMAT (A40)                                                    I330....
C                                                                     I340....
   30 OPEN (UNIT=72,FILE=NEWFILE,STATUS='NEW',ERR=40,IOSTAT=ISTAT)    I350....
   40 IF (ISTAT.NE.0) THEN                                            I360....
         WRITE (1,45) NEWFILE                                         I370....
         GOTO 10                                                      I380....
      END IF                                                          I390....
C                                                                     I400....
   45 FORMAT (/10X,'*********************************************'    I410....
     1        /10X,'    ERROR IN OPENING FILE => ',A40,               I420....
     2        /10X,'*********************************************')   I430....
C                                                                     I440....
C.....Write plot parameters common to all plots                       I450....
      WRITE (72,400) PLOTYPE                                          I460....
      WRITE (72,405) LXNAME                                           I470....
      WRITE (72,405) LYNAME                                           I480....
      WRITE (72,410)       PAGEX,PAGEY                                I490....
      WRITE (72,410)       XAXIS,YAXIS                                I500....
      WRITE (72,410)       XINT,YINT                                  I510....
      WRITE (72,410)       XMIN,YMIN                                  I520....
      WRITE (72,410)       XMAX,YMAX                                  I530....
      WRITE (72,418)                                                  I540....
C                                                                     I550....
```

Program listing -- continued

```
      IF (PLOTYPE.EQ.'MESH'.OR.PLOTYPE.EQ.'VECT') GOTO 100          I560....
C                                                                   I570....
C.....Write contour plot parameters                                 I580....
      WRITE (72,425) CONTYPE,CONTX                                  I590....
      WRITE (72,435) IXDIM,IYDIM,IDIR,NUMDIR                        I600....
      WRITE (72,430) IGRID,IZIN,ISCAL                               I610....
      WRITE (72,430) MODE,LBLFLG,ITHICK                             I620....
      WRITE (72,420) ZINCR,UBASE,UMULT                              I630....
C.....Write gridding data of F-E interpolator was used              I640....
      IF (ISAVE.EQ.1.AND.IGRID.EQ.2.AND.ITYPE.EQ.1)                 I650....
     1   WRITE (72,450) (LNUM(I),I=1,IXDIM*IYDIM)                  I660....
      GOTO 500                                                      I670....
C                                                                   I680....
  100 IF (PLOTYPE.EQ.'MESH') GOTO 200                               I690....
C                                                                   I700....
C.....Write vector plot parameters                                  I710....
      WRITE (72,435) IVEC,ILSCL,IASCL,ISKIP                         I720....
      WRITE (72,440) VPSCL,VLSCL                                    I730....
      GOTO 500                                                      I740....
C                                                                   I750....
C.....Write mesh plot parameter                                     I760....
  200 WRITE (72,430) ISIDE                                          I770....
      IF (ISIDE.EQ.3) THEN                                          I780....
         WRITE (72,460) NCOUNT                                      I790....
         WRITE (72,450) (NODEP(I),I=1,NCOUNT)                       I800....
      END IF                                                        I810....
C                                                                   I820....
  400 FORMAT (A4)                                                   I830....
  405 FORMAT (A60)                                                  I840....
  410 FORMAT (10X,2F15.5)                                           I850....
  418 FORMAT ('------------------------------')                     I860....
  420 FORMAT (3F15.5)                                               I870....
  425 FORMAT (A4,5X,A4)                                             I880....
  430 FORMAT (3I10)                                                 I890....
  435 FORMAT (4I10)                                                 I900....
  440 FORMAT (F10.4,E10.2)                                          I910....
  450 FORMAT (16I5)                                                 I920....
  460 FORMAT (I5)                                                   I930....
  500 CLOSE (72)                                                    I940....
  600 RETURN                                                        I950....
      END                                                           I960....
```

Program listing -- continued

```
C     ***              S U B R O U T I N E   E D I T                    J10.....
C     ***                      Version 1086S                            J20.....
C     *** Purpose:                                                      J30.....
C     ***    Display and interactively change plotting parameters.      J40.....
C     ***    Routine is menu driven and self-contained                  J50.....
C                                                                       J60.....
      SUBROUTINE EDIT                                                   J70.....
      CHARACTER REPLY                                                   J80.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                                 J90.....
      CHARACTER*7 PLOTNAME                                              J100....
      CHARACTER*60 LXNAME,LYNAME,LXTEMP,LYTEMP,TNAME                    J110....
      CHARACTER*40 SUTRA5,SUTRA6                                        J120....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                   J130....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,              J140....
     1             YMIN,YINT,YMAX,                                      J150....
     2             IPLOT,NPLOT,IREAD,                                   J160....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                  J170....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                   J180....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                   J190....
     2                 ZINCR,UBASE,UMULT                                J200....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP           J210....
      COMMON /MESH/ ISIDE,NCOUNT                                        J220....
C                                                                       J230....
      IF (PLOTYPE.EQ.'CONT') PLOTNAME='CONTOUR'                         J240....
      IF (PLOTYPE.EQ.'VECT') PLOTNAME='VECTOR'                          J250....
      IF (PLOTYPE.EQ.'MESH') PLOTNAME='MESH'                            J260....
C                                                                       J270....
   90 WRITE (1,100)                                                     J280....
C                                                                       J290....
C.....Main edit menu                                                    J300....
      WRITE (1,110) PLOTNAME,PAGEX,PAGEY,XAXIS,YAXIS,                   J310....
     1              XINT,YINT,XMIN,YMIN,XMAX,YMAX,                      J320....
     2              LXNAME,LYNAME                                       J330....
      CALL NCHECK(13,IVAR,ISTAT)                                        J340....
      IF (IVAR.EQ.0)  GOTO  90                                          J350....
      IF (IVAR.EQ.1)  GOTO 190                                          J360....
      IF (IVAR.EQ.99) GOTO 600                                          J370....
      IF (IVAR.LT.12.AND.IVAR.GT.3) THEN                                J380....
         WRITE (1,500)                                                  J390....
         READ (1,*,ERR=180) VALUE                                       J400....
      END IF                                                            J410....
      GOTO (190,160,160,114,115,116,117,118,119,120,121,130,145) IVAR   J420....
C                                                                       J430....
  100 FORMAT                                                            J440....
     1(//10X,'=================================================='       J450....
     2  /10X,'              E D I T    S E T U P S'                    J460....
     3  /10X,'==================================================')      J470....
  110 FORMAT (/10X,'     Current PLOT LAYOUT parameters'                J480....
     1  /10X,'  Enter number of plot layout parameter to change'        J490....
     2  /10X,'             (enter <X> to EXIT edit)'                   J500....
     3  /10X,'--------------------------------------------------'       J510....
     4  /10X,' 1) LIST ',A7,' PLOT PARAMETERS'                         J520....
     5  /10X,'    PAGEX=',F8.2,6X,'PAGEY=',F8.2,                       J530....
     5  /10X,' 2) Change page dimensions and re-scale axis lengths'    J540....
     6  /10X,' 3) Change page dimensions ONLY'                         J550....
```

Program listing -- continued

```
     7  /10X,' 4) X-axis length, in inches: XAXIS=',F8.2,                J560....
     8  /10X,' 5) Y-axis length, in inches: YAXIS=',F8.2,                J570....
     9  /10X,' 6) X-interval for ticks, model units: XINT=',F12.4,       J580....
     A  /10X,' 7) Y-interval for ticks, model units: YINT=',F12.4,       J590....
     B  /10X,' 8) Minimum X-coordinate: XMIN=',F15.5,                    J600....
     C  /10X,' 9) Minimum Y-coordinate: YMIN=',F15.5,                    J610....
     D  /10X,'10) Maximum X-coordinate: XMAX=',F15.5,                    J620....
     E  /10X,'11) Maximum Y-coordinate: YMAX=',F15.5,                    J630....
     F  /10X,'12) X-axis label: LXNAME= ',A40,                           J640....
     G  /10X,'13) Y-axis label: LYNAME= ',A40,                           J650....
     H  /10X,'-------------------------------------------------')        J660....
C                                                                        J670....
  114 XAXIS=VALUE                                                        J680....
      GOTO 90                                                            J690....
  115 YAXIS=VALUE                                                        J700....
      GOTO 90                                                            J710....
  116 XINT=VALUE                                                         J720....
      GOTO 90                                                            J730....
  117 YINT=VALUE                                                         J740....
      GOTO 90                                                            J750....
  118 XMIN=VALUE                                                         J760....
      GOTO 90                                                            J770....
  119 YMIN=VALUE                                                         J780....
      GOTO 90                                                            J790....
  120 XMAX=VALUE                                                         J800....
      GOTO 90                                                            J810....
  121 YMAX=VALUE                                                         J820....
      GOTO 90                                                            J830....
C                                                                        J840....
  130 WRITE (1,135)                                                      J850....
  135 FORMAT (/10X,'Enter text for X-axis label')                        J860....
      READ (1,550,ERR=180) TNAME                                         J870....
  140 LXNAME = TNAME                                                     J880....
      GOTO 90                                                            J890....
  145 WRITE (1,142)                                                      J900....
  142 FORMAT (/10X,'Enter text for Y-axis label')                        J910....
      READ (1,550,ERR=180) TNAME                                         J920....
  155 LYNAME = TNAME                                                     J930....
      GOTO 90                                                            J940....
  160 WRITE (1,162)                                                      J950....
      READ (1,*,ERR=180) XVALUE,YVALUE                                   J960....
  162 FORMAT (/10X,'Enter plotting page size in inches (X,Y)')           J970....
      PAGEX=XVALUE                                                       J980....
      PAGEY=YVALUE                                                       J990....
      IF (IVAR.EQ.3) GOTO 90                                             J1000...
      XRANGE=XMAX-XMIN                                                   J1010...
      YRANGE=YMAX-YMIN                                                   J1020...
      IF (PAGEY/YRANGE.LT.PAGEX/XRANGE) THEN                             J1030...
         YAXIS=PAGEY-2.0                                                 J1040...
         XAXIS=XRANGE/YRANGE*YAXIS                                       J1050...
      ELSE                                                               J1060...
         XAXIS=PAGEX-2.0                                                 J1070...
         YAXIS=YRANGE/XRANGE*XAXIS                                       J1080...
      END IF                                                             J1090...
      WRITE (1,164) XRANGE,XAXIS,YRANGE,YAXIS                            J1100...
```

```
      READ (1,550) REPLY                                                    J1110...
  164 FORMAT (/10X,'Plotted axis lengths will be automatically'             J1120...
     1        /10x,'   re-scaled to the new page dimensions'               J1130...
     2        /10X,'----------------------------------------'              J1140...
     3        /10X,' X-coordinate range = ',F10.2,' (model units)'         J1150...
     4        /10X,' X-axis will be set = ',F10.2,' inches'                J1160...
     5       //10X,' Y-coordinate range = ',F10.2,' (model units)'         J1170...
     6        /10X,' Y-axis will be set = ',F10.2,' inches'                J1180...
     7        /10X,'Axis settings may be changed in main EDIT menu'        J1190...
     8        /10X,'       (Press <RETURN> to continue)')                  J1200...
      GOTO 90                                                               J1210...
  180 WRITE (1,560)                                                         J1220...
      READ (1,550) REPLY                                                    J1230...
      GOTO 90                                                               J1240...
  190 IF (PLOTYPE.EQ.'VECT') GOTO 300                                       J1250...
      IF (PLOTYPE.EQ.'MESH') GOTO 400                                       J1260...
C                                                                           J1270...
C.....Contour edit menu                                                     J1280...
  200 WRITE (1,240) IGRID,IXDIM,IYDIM,ISCAL,UBASE,UMULT,IZIN,ZINCR,         J1290...
     1              MODE,LBLFLG,ITHICK                                     J1300...
      CALL NCHECK(10,IVAR,ISTAT)                                            J1310...
      IF (IVAR.EQ.0)  GOTO 200                                              J1320...
      IF (IVAR.EQ.99) GOTO 600                                              J1330...
  210 WRITE (1,500)                                                         J1340...
      GOTO (245,222,223,224,225,226,227,228,229,230) IVAR                   J1350...
C                                                                           J1360...
  222 WRITE (1,510)                                                         J1370...
      READ (1,*,ERR=235) IVALX,IVALY                                        J1380...
      IXDIM=IVALX                                                           J1390...
      IYDIM=IVALY                                                           J1400...
      ITYPE=0                                                               J1410...
      GOTO 200                                                              J1420...
  223 READ (1,520,ERR=235) ITEMP                                            J1430...
      IF (ITEMP.GT.1) GOTO 235                                              J1440...
      ISCAL=ITEMP                                                           J1450...
      GOTO 200                                                              J1460...
  224 READ (1,*,ERR=235) UBASE                                              J1470...
      GOTO 200                                                              J1480...
  225 READ (1,*,ERR=235) UMULT                                              J1490...
      GOTO 200                                                              J1500...
  226 READ (1,520,ERR=235) ITEMP                                            J1510...
      IF (ITEMP.GT.1) GOTO 235                                              J1520...
      IZIN=ITEMP                                                            J1530...
      GOTO 200                                                              J1540...
  227 READ (1,*,ERR=235) ZINCR                                              J1550...
      GOTO 200                                                              J1560...
  228 CALL NCHECK(5,MODE,ISTAT)                                             J1570...
      GOTO 200                                                              J1580...
  229 CALL NCHECK(2,LBLFLG,ISTAT)                                           J1590...
      GOTO 200                                                              J1600...
  230 READ (1,520,ERR=235) ITHICK                                           J1610...
      GOTO 200                                                              J1620...
  235 WRITE (1,560)                                                         J1630...
      READ (1,550) REPLY                                                    J1640...
      GOTO 200                                                              J1650...
```

Program listing -- continued

```
C                                                                       J1660...
  240 FORMAT (/10X,'   Enter number of CONTOUR parameter to change'     J1670...
     1        /10X,'            (enter <X> to EXIT edit)'               J1680...
     2        /10X,'-------------------------------------------------'  J1690...
     3        /10X,' 1) GRIDDING method flag:  IGRID=',I2,             J1700...
     4        /10X,'    (1=DISSPLA  2=Finite-element  3=No gridding)'  J1710...
     5        /10X,' 2) Gridding dimensions:   IXDIM=',I3,             J1720...
     6        /10X,'                           IYDIM=',I3,             J1730...
     7       //10X,' 3) DATA SCALING flag:     ISCAL=',I2,             J1740...
     8        /10X,'    (0=no scaling  1=scaled w/UMULT & UBASE)'      J1750...
     9        /10X,' 4) Scaling factor:        UBASE=',F15.6,          J1760...
     A        /10X,' 5) Scaling factor:        UMULT=',F15.6,          J1770...
     B        /10X,'    (Plotted data=[true data/UBASE]*UMULT )'      J1780...
     C       //10X,' 6) CONTOUR INTERVAL flag: IZIN=',I2,              J1790...
     D        /10X,'    (0=interval is ZINCR   1=Selected by DISSPLA)' J1800...
     E        /10X,' 7) Contour interval:      ZINCR=',F10.4,          J1810...
     F        /10X,' 8) Contour line type:     MODE=',I2,              J1820...
     G        /10X,'    (1=dot  2=dash  3=chn-dot  4=chn-dash  5=solid' J1830...
     H        /10X,' 9) Line labeling flag:    LBLFLG=',I2,            J1840...
     I        /10X,'    (1=labels  2=no labels)'                       J1850...
     J        /10X,'10) Contour line thickness:ITHICK=',I3,           J1860...
     K        /10X,'    (eg, 5=.05 inch thick)')                       J1870...
C                                                                       J1880...
  245 CALL NCHECK (3,IVALUE,ISTAT)                                      J1890...
      IF (IVALUE.NE.3) THEN                                             J1900...
         IGRID=IVALUE                                                   J1910...
         GOTO 200                                                       J1920...
      END IF                                                            J1930...
C                                                                       J1940...
  250 WRITE (1,260) IXDIM,IYDIM,NUMDIR                                  J1950...
      CALL NCHECK(5,IVAR,ISTAT)                                         J1960...
      IF (IVAR.EQ.0) GOTO 250                                           J1970...
      IF (IVAR.GT.3) THEN                                               J1980...
         IF (IVAR.EQ.4) IGRID=3                                         J1990...
         GOTO 200                                                       J2000...
      END IF                                                            J2010...
      IF (IVAR.EQ.99) GOTO 600                                          J2020...
      WRITE (1,500)                                                     J2030...
      READ (1,520,ERR=258) IVALUE                                       J2040...
      GOTO (251,252,253,200) IVAR                                       J2050...
  251 IXDIM=IVALUE                                                      J2060...
      GOTO 250                                                          J2070...
  252 IYDIM=IVALUE                                                      J2080...
      GOTO 250                                                          J2090...
  253 IF (IVALUE.GT.1) GOTO 258                                         J2100...
      NUMDIR=IVALUE                                                     J2110...
      GOTO 250                                                          J2120...
  258 WRITE (1,560)                                                     J2130...
      READ (1,550) REPLY                                                J2140...
      GOTO 250                                                          J2150...
C                                                                       J2160...
  260 FORMAT (/10X,'*****************   CAUTION   *********************'J2170...
     1        /10X,'         <<NO GRIDDING>> OPTION SELECTED'           J2180...
     2        /10X,'************************************************'  J2190...
     3        /10X,'   Data may be contoured without gridding ONLY if'  J2200...
```

Program listing -- continued

```
     4        /10X,' the finite-element mesh is RECTANGULAR and REGULAR'J2210...
     5        /10X,'  The number of rows and columns for the grid must' J2220...
     6        /10x,'   be set equal to the number of rows and columns'  J2230...
     7        /10x,'             in the finite-element mesh'            J2240...
     8        /10X,'       ** Mesh numbering flag MUST be set **'       J2250...
     9        /10X,'=============================================='J2260...
     A        /10X,'  Select one:'                                      J2270...
     B        /10X,'    Change: '                                      J2280...
     C        /10X,'  1) X-grid-dimension:      IXDIM=',I3,           J2290...
     D        /10X,'  2) Y-grid-dimension:      IYDIM=',I3,           J2300...
     E        /10X,'  3) Mesh numbering flag:   NUMDIR=',I2,          J2310...
     F        /10X,'     0=mesh numbered along rows'                    J2320...
     G        /10X,'     1=mesh numbered along columns'                 J2330...
     H       //10X,'  4)Use   <<No gridding>> option'                   J2340...
     I        /10X,'  5)ABORT <<No gridding>> option')                  J2350...
C                                                                       J2360...
  300 IARRW=MOD(IVEC/10,10)+1                                           J2370...
      ISIZE=MOD(IVEC/100,10)                                            J2380...
C                                                                       J2390...
C.....Vector plot edit menu                                             J2400...
  310 WRITE (1,340) VPSCL,ILSCL,IASCL,IARRW,ISIZE,ISKIP,VLSCL           J2410...
      CALL NCHECK(7,IVAR,ISTAT)                                         J2420...
      IF (IVAR.EQ.0)  GOTO 310                                          J2430...
      IF (IVAR.EQ.99) GOTO 600                                          J2440...
      WRITE (1,500)                                                     J2450...
      GOTO (331,332,333,334,335,336,337) IVAR                           J2460...
C                                                                       J2470...
  331 READ (1,*,ERR=390) VALUE                                          J2480...
      VPSCL=VALUE                                                       J2490...
      GOTO 310                                                          J2500...
  332 CALL NCHECK(2,ILSCL,ISTAT)                                        J2510...
      GOTO 310                                                          J2520...
  333 READ (1,520,ERR=390) IVALUE                                       J2530...
      IF (IVALUE.GT.1) GOTO 390                                         J2540...
      IASCL=IVALUE                                                      J2550...
      GOTO 310                                                          J2560...
  334 CALL NCHECK(3,IVALUE,ISTAT)                                       J2570...
      IVEC=IVEC-((IARRW-1)*10)+((IVALUE-1)*10)                          J2580...
      IARRW=IVALUE                                                      J2590...
      GOTO 310                                                          J2600...
  335 CALL NCHECK(6,IVALUE,ISTAT)                                       J2610...
      IVEC=IVEC-(ISIZE*100)+(IVALUE*100)                                J2620...
      ISIZE=IVALUE                                                      J2630...
      GOTO 310                                                          J2640...
  336 READ (1,520,ERR=390) IVALUE                                       J2650...
      ISKIP=IVALUE                                                      J2660...
      GOTO 310                                                          J2670...
  337 READ (1,*,ERR=390) VALUE                                          J2680...
      VLSCL=VALUE                                                       J2690...
      GOTO 310                                                          J2700...
C                                                                       J2710...
  340 FORMAT (/10X,'    Current VECTORPLOT parameters'                  J2720...
     1        /10X,'Enter number of plot parameter to change'          J2730...
     2        /10X,'         (enter <X> to EXIT edit)'                 J2740...
     3        /10X,'-----------------------------------'               J2750...
```

Program listing -- continued

```
     4        /10X,'1) Plotted length of largest vector: VPSCL=',F4.2,  J2760...
     5        /10X,'2) Vector length scaling flag:       ILSCL=',I2,    J2770...
     6        /10X,'   (1=linear  2=logarithmic)'                       J2780...
     7        /10X,'3) Direction angle scaling flag:     IASCL=',I2,    J2790...
     8        /10X,'   (0=no scaling  1=scale angles)'                  J2800...
     9        /10X,'4) Arrowhead type:                   IARRW=',I2,    J2810...
     A        /10X,'   (1=solid  2=empty  3=stick)'                     J2820...
     B        /10X,'5) Arrowhead size, in inches:        ISIZE=',I2,    J2830...
     C        /10X,'   (1=.075  2=.15  3=.225  4=.3  5=.375  6=.45)'    J2840...
     D       //10X,'   Vector thinning options:'                         J2850...
     E        /10X,'6)   Plot every ',I2,'th vector'                    J2860...
     F        /10x,'7)   Skip vectors less than',1PE10.3,' of the'      J2870...
     G        /10X,'     largest vector')                               J2880...
C                                                                       J2890...
  390 WRITE (1,560)                                                     J2900...
      READ (1,550) REPLY                                                J2910...
      GOTO 310                                                          J2920...
C                                                                       J2930...
C.....Mesh plot edit menu                                               J2940...
  400 WRITE (1,460) ISIDE                                               J2950...
      CALL NCHECK(3,IVALUE,ISTAT)                                       J2960...
      IF (IVALUE.EQ.0)  GOTO 400                                        J2970...
      IF (IVALUE.EQ.99) GOTO 600                                        J2980...
      ISIDE=IVALUE                                                      J2990...
      GOTO 400                                                          J3000...
C                                                                       J3010...
  460 FORMAT (/10X,'          MESHPLOT Parameter'                       J3020...
     1        /10X,'       Enter <X> to EXIT edit'                     J3030...
     2        /10X,'-------------------------------------'              J3040...
     3        /10X,'   Side plotting flag: ISIDE=',I2,                 J3050...
     4        /10X,'1= plots all sides of all elements using'          J3060...
     5        /10X,'     incidence list'                               J3070...
     6        /10X,'2= plots mesh without duplicating sides'           J3080...
     7        /10X,'3= plots perimeter of mesh only'                   J3090...
     8       //10X,'        Input new value'                           J3100...
     9        /10X,'=====================================')            J3110...
C                                                                       J3120...
  500 FORMAT (/10X,'  Enter new value(s) or option code'                J3130...
     1        /10X,'  --------------------------------')               J3140...
  510 FORMAT (/10X,'IXDIM,IYDIM  (free format)')                        J3150...
  520 FORMAT (I5)                                                       J3160...
  550 FORMAT (A)                                                        J3170...
  560 FORMAT (/10X,'**************  INPUT ERROR  **************'        J3180...
     1        /10X,'************  OR INVALID ENTRY  ************'      J3190...
     2        /10X,'*******  Press <RETURN> to continue  *******')     J3200...
  600 RETURN                                                            J3210...
      END                                                               J3220...
```

Program listing -- continued

```
C     ***              S U B R O U T I N E   P L O T                    K10.....
C     ***                      Version 1086S                            K20.....
C     *** Purpose:                                                      K30.....
C     ***    Initializes DISSPLA for all plots and calls specific       K40.....
C     ***    plot routine.  After plot, returns control of program      K50.....
C     ***    to main menu in SUTRAPLOT.                                 K60.....
C                                                                       K70.....
      SUBROUTINE PLOT(X,Y,U,XYMAX,VMAG,VANG,                            K80.....
     1               UGRID,UMAT,                                        K90.....
     2               IXY,IN,LNUM,NODEP)                                 K100....
      DOUBLE PRECISION X,Y,U,XYMAX,VMAG,VANG                            K110....
      CHARACTER REPLY,BLANK                                             K120....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                                 K130....
      CHARACTER*60 TNAME,LXNAME,LYNAME                                  K140....
      CHARACTER*40 SUTRA6                                               K150....
      CHARACTER*6 LINE(5)                                               K160....
      CHARACTER*8 LABEL(2)                                              K170....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                   K180....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,              K190....
     1             YMIN,YINT,YMAX,                                      K200....
     2             IPLOT,NPLOT,IREAD,                                   K210....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                  K220....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                   K230....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                   K240....
     2                 ZINCR,UBASE,UMULT                                K250....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP           K260....
      COMMON /MESH/ ISIDE,NCOUNT                                        K270....
      COMMON WORK(100000)                                               K280....
      DIMENSION X(NN),Y(NN),U(NN)                                       K290....
      DIMENSION VMAG(NE),VANG(NE),XYMAX(NE)                             K300....
      DIMENSION IN(NE,4),IXY(NE),LNUM(IXDIM*IYDIM),NODEP(500)           K310....
      DIMENSION UMAT(IXDIM,IYDIM),UGRID(IXDIM*IYDIM)                    K320....
      DATA LINE /'DOT','DASH','CHNDOT','CHNDSH','SOLID'/                K330....
      DATA LABEL /'LABELS','NOLABELS'/                                  K340....
      DATA BLANK /' '/                                                  K350....
C                                                                       K360....
C.....Error messages and diagnostics are written to 'PLOT.OUT'          K370....
      OPEN (79, FILE='PLOT.OUT')                                        K380....
C                                                                       K390....
   21 IF (PLOTYPE.NE.'MESH') THEN                                       K400....
         IF (IREAD.EQ.1) GOTO 24                                        K410....
         WRITE (1,25)                                                   K420....
         READ (1,30) SUTRA6                                             K430....
         IF (SUTRA6.EQ.'A'.OR.SUTRA6.EQ.'a') RETURN                     K440....
         IF (SUTRA6.EQ.'') GOTO 21                                      K450....
         OPEN (UNIT=77,FILE=SUTRA6,STATUS='OLD',ERR=22,IOSTAT=ISTAT)    K460....
   22    IF (ISTAT.NE.0) THEN                                           K470....
            WRITE (1,40) SUTRA6                                         K480....
            GOTO 21                                                     K490....
         END IF                                                         K500....
   24    CALL READ6(U,VMAG,VANG)                                        K510....
         IF (IPLOT.EQ.0) GOTO 400                                       K520....
      END IF                                                            K530....
   25 FORMAT (/10X,'Enter pathname of SUTRA OUTPUT file'                 K540....
     1        /10X,'  (enter <A> to abort this plot)'                   K550....
```

Program listing -- continued

```
     2        /10X,'==================================')                K560....
   30 FORMAT (A40)                                                      K570....
   40 FORMAT (/10X,'************************************************'  K580....
     1        /10X,'     ERROR IN OPENING FILE => ',A40,               K590....
     2        /10X,'************************************************') K600....
C                                                                       K610....
      IF (IPLOT.EQ.0) RETURN                                            K620....
C                                                                       K630....
C.....Set 'zero' coordinates to exactly 0.0 (DISSPLA/PRIME quirk)       K640....
C                                                                       K650....
      IF (XMIN.LT.1.E-6.AND.XMIN.GT.-1.E-6) XMIN=0.0                    K660....
      IF (YMIN.LT.1.E-6.AND.YMIN.GT.-1.E-6) YMIN=0.0                    K670....
      IF (XMAX.LT.1.E-6.AND.XMAX.GT.-1.E-6) XMAX=0.0                    K680....
      IF (YMAX.LT.1.E-6.AND.YMAX.GT.-1.E-6) YMAX=0.0                    K690....
C                                                                       K700....
C.....Select output device                                              K710....
  100 CALL OUTDEV(IDEV)                                                 K720....
C                                                                       K730....
C.....Initialize DISSPLA                                                K740....
      CALL RESET ('ALL')                                                K750....
      CALL SETDEV(79,79)                                                K760....
      CALL NOBRDR                                                       K770....
      CALL GRACE (1.0)                                                  K780....
      CALL PAGE (PAGEX,PAGEY)                                           K790....
      CALL AREA2D (XAXIS,YAXIS)                                         K800....
      IF (IDEV.EQ.1) CALL HEIGHT(.2)                                    K810....
      IF (PLOTYPE.EQ.'MESH') GOTO 200                                   K820....
C                                                                       K830....
C.....Eliminate trailing blanks from X-axis label                       K840....
      DO 112 IX=LEN(LXNAME),1,-1                                        K850....
         IF (LXNAME((IX):(IX)).NE.BLANK) GOTO 114                       K860....
  112 CONTINUE                                                          K870....
C.....Then add a '$' to the end of the X-axis label for                 K880....
C.....  DISSPLA self-counting option                                    K890....
  114 IF (LXNAME((IX):(IX)).EQ.'$') THEN                                K900....
         TNAME = LXNAME                                                 K910....
      ELSE                                                              K920....
         TNAME = LXNAME(1:IX)//'$'                                      K930....
      END IF                                                            K940....
      CALL XNAME (TNAME,100)                                            K950....
C.....Same for Y-axis label                                             K960....
      DO 122 IY=LEN(LYNAME),1,-1                                        K970....
         IF (LYNAME((IY):(IY)).NE.BLANK) GOTO 124                       K980....
  122 CONTINUE                                                          K990....
  124 IF (LYNAME((IY):(IY)).EQ.'$') THEN                                K1000...
          TNAME = LYNAME                                                K1010...
      ELSE                                                              K1020...
          TNAME = LYNAME(1:IY)//'$'                                     K1030...
      END IF                                                            K1040...
  125 FORMAT (A)                                                        K1050...
      CALL YNAME (TNAME,100)                                            K1060...
      CALL YAXANG(0.)                                                   K1070...
      CALL XREVTK                                                       K1080...
      CALL YREVTK                                                       K1090...
      CALL GRAF (XMIN,XINT,XMAX,YMIN,YINT,YMAX)                         K1100...
```

Program listing -- continued

```
      CALL THKFRM (.01)                                                  K1110...
      CALL FRAME                                                         K1120...
C                                                                        K1130...
 200  IF (PLOTYPE.EQ.'MESH')                                             K1140...
     1   CALL MESHP(X,Y,IN,NODEP)                                        K1150...
C                                                                        K1160...
      IF (PLOTYPE.EQ.'VECT')                                             K1170...
     1   CALL VECPLT(X,Y,VMAG,VANG,IN)                                   K1180...
C                                                                        K1190...
      IF (PLOTYPE.EQ.'CONT')                                             K1200...
     1   CALL KONTUR(X,Y,U,XYMAX,UGRID,UMAT,                             K1210...
     2               IXY,IN,LNUM)                                        K1220...
C                                                                        K1230...
      CALL ENDPL (0)                                                     K1240...
      CALL DONEPL                                                        K1250...
C                                                                        K1260...
C.....End of plot                                                        K1270...
C                                                                        K1280...
C.....Set flag to indicate plot with current setup and data file         K1290...
      NPLOT=1                                                            K1300...
      REWIND (75)                                                        K1310...
      IF (IDEV.EQ.2.OR.IDEV.EQ.3) GOTO 290                               K1320...
C                                                                        K1330...
C.....Screen clearing prompt for CRT devices                             K1340...
      WRITE (1,280)                                                      K1350...
      READ (1,285) REPLY                                                 K1360...
  280 FORMAT (10X,'-----------------------------------------'            K1370...
     1       /10X,'* * * *    C L E A R    S C R E E N    * * * *'      K1380...
     2       /10X,'* * * *   PRESS <RETURN> TO CONTINUE   * * * *'      K1390...
     3       /10X,'-----------------------------------------')          K1400...
  285 FORMAT (A)                                                         K1410...
  290 IF (PLOTYPE.EQ.'MESH') GOTO 400                                    K1420...
C                                                                        K1430...
      WRITE (1,300)                                                      K1440...
      CALL QCHECK(IPLOT,ISTAT)                                           K1450...
      IF (IPLOT.EQ.1) THEN                                               K1460...
         CALL READ6(U,VMAG,VANG)                                         K1470...
         IF (IPLOT.EQ.0) GOTO 400                                        K1480...
         GOTO 100                                                        K1490...
      END IF                                                             K1500...
  300 FORMAT (/10X,'Plot another time step in this file? (Y/N?)')         K1510...
C                                                                        K1520...
  400 RETURN                                                             K1530...
      END                                                                K1540...
```

Program listing -- continued

```
C     ***          S U B R O U T I N E   R E A D 5                    L10.....
C     ***                    Version 1086S                            L20.....
C     *** Purpose:                                                    L30.....
C     ***    Reads node coordinates and incidence list from SUTRA     L40.....
C     ***    input data file.                                         L50.....
C                                                                     L60.....
      SUBROUTINE READ5(X,Y,IN)                                        L70.....
      DOUBLE PRECISION X,Y,XSCALE,YSCALE,XX,XN,YX,YN                  L80.....
      CHARACTER REPLY                                                 L90.....
      CHARACTER*6 STRNG                                               L100....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                               L110....
      CHARACTER*60 LXNAME,LYNAME                                      L120....
      CHARACTER*4 UTX,SIMULA                                          L130....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                 L140....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,            L150....
     1             YMIN,YINT,YMAX,                                    L160....
     2             IPLOT,NPLOT,IREAD,                                 L170....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                L180....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP         L190....
      COMMON /MESH/ ISIDE,NCOUNT                                      L200....
      DIMENSION X(NN),Y(NN),IN(NE,4)                                  L210....
      DATA NSTEP/0/                                                   L220....
C                                                                     L230....
      IPLOT=1                                                         L240....
      WRITE (1,20)                                                    L250....
   20 FORMAT (/10X,'******  Reading SUTRA INPUT DATA file  ******'/)  L260....
      READ (75,30) SIMULA                                             L270....
   30 FORMAT (6X,A4)                                                  L280....
   50 CALL SKIP(75)                                                   L290....
      CALL SKIP(75)                                                   L300....
      READ (75,110) NN,NE,NPBC,NUBC,NSOP,NSOU,NOBS                    L310....
  110 FORMAT(2I5,10X,5I5)                                             L320....
      READ (75,110) IUNSAT,ISSFLO                                     L330....
      CALL SKIP(75)                                                   L340....
      READ(75,112) ITMAX                                              L350....
  112 FORMAT (I5)                                                     L360....
      READ(75,114) NPRINT,KPLOTP,KPLOTU,KVEL                          L370....
  114 FORMAT(I5,15X,3I5)                                              L380....
      KPLOT=KPLOTP+KPLOTU                                             L390....
C                                                                     L400....
      DO 115 I=1,6                                                    L410....
  115    CALL SKIP(75)                                                L420....
      READ(75,117) XSCALE,YSCALE                                      L430....
  117 FORMAT(5X,2G10.4)                                               L440....
C                                                                     L450....
C.....Initialize maximum and minimum node coordinates                 L460....
      XN=1.E9                                                         L470....
      XX=0.0                                                          L480....
      YN=1.E9                                                         L490....
      YX=0.0                                                          L500....
C                                                                     L510....
      DO 125 J=1,NN                                                   L520....
         READ(75,120)I,X(I),Y(I)                                      L530....
  120    FORMAT(I5,2G10.4)                                            L540....
         X(I)= X(I) * XSCALE                                          L550....
```

Program listing -- continued

```
         Y(I)= Y(I) * YSCALE                                          L560....
C.....Calculate and save max and min coordinates                      L570....
         IF (X(I).LT.XN) XN=X(I)                                      L580....
         IF (X(I).GT.XX) XX=X(I)                                      L590....
         IF (Y(I).LT.YN) YN=Y(I)                                      L600....
  125    IF (Y(I).GT.YX) YX=Y(I)                                      L610....
      XMIN=FLOAT(XN)                                                  L620....
      XMAX=FLOAT(XX)                                                  L630....
      YMIN=FLOAT(YN)                                                  L640....
      YMAX=FLOAT(YX)                                                  L650....
      CALL SKIP(75)                                                   L660....
C                                                                     L670....
C.....Skip elementwise data                                           L680....
      DO 130 L=1,NE                                                   L690....
         CALL SKIP(75)                                                L700....
  130 CONTINUE                                                        L710....
C                                                                     L720....
C.....Skip BC's, observation data, etc                                L730....
      IF(KPLOT.LE.0) GOTO 150                                         L740....
      CALL SKIP(75)                                                   L750....
      IF(KPLOTP.NE.+1) GOTO 140                                       L760....
      CALL SKIP(75)                                                   L770....
  140 IF(KPLOTU.NE.+1) GOTO 150                                       L780....
      CALL SKIP(75)                                                   L790....
  150 IF(NSOP.EQ.0) GOTO 162                                          L800....
      DO 160 I=1,NSOP                                                 L810....
  160    CALL SKIP(75)                                                L820....
      CALL SKIP(75)                                                   L830....
  162 IF(NSOU.EQ.0) GOTO 170                                          L840....
      DO 166 I=1,NSOU                                                 L850....
  166    CALL SKIP(75)                                                L860....
      CALL SKIP(75)                                                   L870....
  170 IF(NPBC.EQ.0) GOTO 190                                          L880....
      DO 180 I=1,NPBC                                                 L890....
  180    CALL SKIP(75)                                                L900....
      CALL SKIP(75)                                                   L910....
  190 IF(NUBC.EQ.0) GOTO 250                                          L920....
      DO 200 I=1,NUBC                                                 L930....
  200    CALL SKIP(75)                                                L940....
      CALL SKIP(75)                                                   L950....
  250 IF (NOBS .EQ. 0) GOTO 290                                       L960....
      CALL SKIP(75)                                                   L970....
      DO 270 I=1,(NOBS+16)/16                                         L980....
  270 CALL SKIP(75)                                                   L990....
C                                                                     L1000...
C.....And finally read incidence list                                 L1010...
  290 DO 295 L=1,NE                                                   L1020...
         READ(75,300)LL,(IN(L,J),J=1,4)                               L1030...
         IF (LL .LT. 0.0) CALL SKIP(75)                               L1040...
  295 CONTINUE                                                        L1050...
C                                                                     L1060...
  300 FORMAT(5I6)                                                     L1070...
      RETURN                                                          L1080...
      END                                                             L1090...
```

Program listing -- continued

```
C     ***          S U B R O U T I N E   R E A D 6                    M10.....
C     ***                      Version 1086S                          M20.....
C     *** Purpose:                                                    M30.....
C     ***    Searches for and reads simulation results from          M40.....
C     ***    SUTRA printout file.                                    M50.....
C                                                                     M60.....
      SUBROUTINE READ6(U,VMAG,VANG)                                   M70.....
      DOUBLE PRECISION U,VMAG,VANG                                    M80.....
      CHARACTER REPLY                                                 M90.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                               M100....
      CHARACTER*6 STRNG,SSFLO,SSTRA                                   M110....
      CHARACTER*9 SUTRA                                               M120....
      CHARACTER*60 LXNAME,LYNAME                                      M130....
      CHARACTER*4 UTX,SIMULA                                          M140....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                 M150....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,            M160....
     1             YMIN,YINT,YMAX,                                    M170....
     2             IPLOT,NPLOT,IREAD,                                 M180....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                M190....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                 M200....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                 M210....
     2                 ZINCR,UBASE,UMULT                              M220....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP         M230....
      COMMON /MESH/ ISIDE,NCOUNT                                      M240....
      DIMENSION VMAG(NE),VANG(NE)                                     M250....
      DIMENSION U(NN)                                                 M260....
      DATA NSTEP/0/                                                   M270....
C                                                                     M280....
      IPLOT=1                                                         M290....
      IREAD=1                                                         M300....
C                                                                     M310....
      IF (NPLOT.EQ.1) GOTO 230                                        M320....
      REWIND (77)                                                     M330....
      WRITE (1,150)                                                   M340....
  150 FORMAT (/10X,'******  Reading SUTRA OUTPUT file  ******'/)       M350....
      IFLAG = 0                                                       M360....
  200 IF (IFLAG .EQ. 1) GOTO 230                                      M370....
      KOUNT=0                                                         M380....
  201 READ (77,203,END=595) SUTRA                                     M390....
      KOUNT=KOUNT+1                                                   M400....
      IF (SUTRA.NE.'S U T R A') THEN                                  M410....
         IF (KOUNT.GT.100) THEN                                       M420....
            WRITE (1,204)                                             M430....
            ISTAT=1                                                   M440....
            CLOSE (77)                                                M450....
            RETURN                                                    M460....
         END IF                                                       M470....
         GOTO 201                                                     M480....
      END IF                                                          M490....
  203 FORMAT (32X,A9)                                                 M500....
  204 FORMAT(/10X,'*************************************************'  M510....
     1       /10X,'          ERROR IN READING SUTRA OUTPUT FILE'      M520....
     2       /10X,' File specified is not an unmodified SUTRA OUTPUT' M530....
     3       /10X,'*************************************************') M540....
  205 READ (77,207,END=595) STRNG                                     M550....
```

```
      IF (STRNG.NE.'M O D ') GOTO 205                                  M560....
  207 FORMAT (33X,A6)                                                  M570....
      CALL SKIP(77)                                                    M580....
      CALL SKIP(77)                                                    M590....
C.....Steady-state output flags                                        M600....
      READ (77,209) SSFLO                                              M610....
      READ (77,209) SSTRA                                              M620....
      IF (CONTYPE.EQ.'SATU') GOTO 210                                  M630....
      IF (SSTRA.EQ.'TE TRA') GOTO 350                                  M640....
      IF (SSFLO.EQ.'TE FLO') THEN                                      M650....
         IF (PLOTYPE.EQ.'VECT') THEN                                   M660....
            CONTYPE=' '                                                M670....
            GOTO 350                                                   M680....
         END IF                                                        M690....
         IF (CONTYPE.EQ.'PRES') GOTO 350                               M700....
      END IF                                                           M710....
C                                                                      M720....
  209 FORMAT (30X,A6)                                                  M730....
  210 READ (77,225,END=595) STRNG                                      M740....
      IF (STRNG .NE. 'T E M ') GOTO 210                                M750....
      CALL SKIP(77)                                                    M760....
C                                                                      M770....
C.....ITMAX is maximum number of time steps in printout                M780....
      READ (77,215,END=595) ITMAX                                      M790....
  215 FORMAT (21X,I5)                                                  M800....
  217 READ (77,225,END=595) STRNG                                      M810....
      IF (STRNG .NE. 'O U T ') GOTO 217                                M820....
      CALL SKIP(77)                                                    M830....
C                                                                      M840....
C.....Output is printed every NPRINT time steps                        M850....
      READ (77,218,END=595) NPRINT                                     M860....
  218 FORMAT (12X,I5)                                                  M870....
      CALL SKIP(77)                                                    M880....
      KNODAL=0                                                         M890....
      READ (77,219,END=595) STRNG                                      M900....
      IF (STRNG .NE. 'CANCEL') KNODAL=1                                M910....
      CALL SKIP(77)                                                    M920....
      KINCID=0                                                         M930....
      READ (77,219,END=595) STRNG                                      M940....
      IF (STRNG .NE. 'CANCEL') KINCID=1                                M950....
      CALL SKIP(77)                                                    M960....
      CALL SKIP(77)                                                    M970....
      CALL SKIP(77)                                                    M980....
      CALL SKIP(77)                                                    M990....
      KVEL=0                                                           M1000...
      READ (77,219,END=595) STRNG                                      M1010...
      IF (STRNG .NE. 'CANCEL') KVEL=1                                  M1020...
  219 FORMAT (13X,A6)                                                  M1030...
  220 READ (77,225,END=595) STRNG                                      M1040...
  225 FORMAT (11X,A6)                                                  M1050...
      IF (STRNG .NE. 'I N I ') GOTO 220                                M1060...
      IFLAG = 1                                                        M1070...
      JFLAG = 0                                                        M1080...
C                                                                      M1090...
C.....Search for first time step in printout                           M1100...
```

Program listing -- continued

```
  230 READ (77,235,END=595) STRNG                                    M1110...
  235 FORMAT (23X,A6)                                                M1120...
      IF (STRNG .NE. 'TIME S') GOTO 230                              M1130...
      BACKSPACE (77)                                                 M1140...
C                                                                    M1150...
C.....KSTEP is the timestep being currently read                     M1160...
      READ (77,240,END=595) KSTEP                                    M1170...
      IF (KSTEP.EQ.0) GOTO 230                                       M1180...
  240 FORMAT (33X,I4)                                                M1190...
C                                                                    M1200...
      IF (JFLAG.EQ.1.AND.KSTEP.NE.JSTEP) GOTO 230                    M1210...
      JFLAG = 0                                                      M1220...
C                                                                    M1230...
C.....Write plot selection menu                                      M1240...
  300 WRITE (1,552) NPRINT                                           M1250...
      WRITE (1,555) ITMAX                                            M1260...
      WRITE (1,558) KSTEP                                            M1270...
      WRITE (1,560)                                                  M1280...
C                                                                    M1290...
  310 READ (1,580,ERR=310) REPLY                                     M1300...
      IF (REPLY .EQ. 'S' .OR. REPLY .EQ. 's') GOTO 200               M1310...
      IF (REPLY .EQ. 'J' .OR. REPLY .EQ. 'j') THEN                   M1320...
  315    WRITE (1,570)                                               M1330...
         READ (1,590) JSTEP                                          M1340...
         IF (JSTEP.LT.KSTEP) REWIND(77)                              M1350...
         IF (JSTEP.GT.ITMAX) THEN                                    M1360...
            WRITE (1,320) JSTEP                                      M1370...
            GOTO 315                                                 M1380...
         END IF                                                      M1390...
         JFLAG = 1                                                   M1400...
         GOTO 200                                                    M1410...
      END IF                                                         M1420...
C                                                                    M1430...
  320 FORMAT (/10X,'Time step ',I5,' larger than the maximum'        M1440...
     1        /10X,'   timestep indicated in the printout'          M1450...
     2        /10X,'****************************************')       M1460...
      IF (REPLY .EQ. 'A' .OR. REPLY .EQ. 'a') THEN                   M1470...
          IPLOT=0                                                    M1480...
          GOTO 900                                                   M1490...
      END IF                                                         M1500...
      IF (REPLY .EQ. 'P' .OR. REPLY .EQ. 'p') GOTO 400               M1510...
      GOTO 310                                                       M1520...
C                                                                    M1530...
C.....Write plot selection menu for steady-state output              M1540...
  350 WRITE (1,608)                                                  M1550...
      IF (CONTYPE.EQ.'CONC') WRITE (1,610)                           M1560...
      IF (CONTYPE.EQ.'TEMP') WRITE (1,612)                           M1570...
      IF (CONTYPE.EQ.'PRES') WRITE (1,614)                           M1580...
      IF (PLOTYPE.EQ.'VECT') WRITE (1,616)                           M1590...
C                                                                    M1600...
  360 WRITE (1,620)                                                  M1610...
      READ (1,580,ERR=310) REPLY                                     M1620...
      IF (REPLY .EQ. 'A' .OR. REPLY .EQ. 'a') THEN                   M1630...
          IPLOT=0                                                    M1640...
          GOTO 900                                                   M1650...
```

Program listing -- continued

```
      END IF                                                              M1660...
      IF (REPLY .EQ. 'P' .OR. REPLY .EQ. 'p') GOTO 428                    M1670...
      GOTO 360                                                            M1680...
C                                                                         M1690...
  400 IF (PLOTYPE.EQ.'VECT') THEN                                         M1700...
         CONTYPE=' '                                                      M1710...
  410    READ(77,450,END=595) UTX                                         M1720...
         IF(UTX.NE.'M A ') GOTO 410                                       M1730...
         READ(77,460) (VMAG(J),J=1,NE)                                    M1740...
  420    READ(77,450,END=595) UTX                                         M1750...
         IF(UTX.NE.'A N ') GOTO 420                                       M1760...
         READ(77,460) (VANG(J),J=1,NE)                                    M1770...
         GOTO 900                                                         M1780...
      ELSE                                                                M1790...
  425    READ (77,450,END=595) UTX                                        M1800...
         IF (UTX .NE. CONTX) GOTO 425                                     M1810...
         READ (77,460,END=595) (U(I),I=1,NN)                              M1820...
         GOTO 900                                                         M1830...
      END IF                                                              M1840...
  428 IF (PLOTYPE.EQ.'VECT') GOTO 400                                     M1850...
      IF (CONTYPE.EQ.'PRES') THEN                                         M1860...
  430    READ (77,445,END=595) UTX                                        M1870...
         IF (UTX.NE.CONTX) GOTO 430                                       M1880...
         READ (77,460,END=595) (U(I),I=1,NN)                              M1890...
         GOTO 900                                                         M1900...
      END IF                                                              M1910...
      IF (CONTYPE.EQ.'CONC'.OR.CONTYPE.EQ.'TEMP') THEN                    M1920...
  435    READ (77,440,END=595) UTX                                        M1930...
         IF (UTX.NE.CONTX) GOTO 435                                       M1940...
         READ (77,460,END=595) (U(I),I=1,NN)                              M1950...
         GOTO 900                                                         M1960...
      END IF                                                              M1970...
C                                                                         M1980...
  440 FORMAT (49X,A4)                                                     M1990...
  445 FORMAT (50X,A4)                                                     M2000...
  450 FORMAT (11X,A4)                                                     M2010...
  460 FORMAT (//(7X,6(6X,G15.8)))                                         M2020...
  552 FORMAT (//10X,'      OUTPUT PRINTED EVERY ',I5,' TIMESTEPS')        M2030...
  555 FORMAT ( /10X,'      LAST TIME STEP IN PRINTOUT => ',I4,            M2040...
     1         /10X,'   ----------------------------------------')       M2050...
  558 FORMAT (/10X,' CURRENTLY READING TIME STEP  **** ',I4,'  ****')     M2060...
  560 FORMAT (/10X,'   (P) PLOT THIS TIME STEP'                           M2070...
     1        /10X,'   (S) SKIP TO NEXT TIME STEP'                       M2080...
     2        /10X,'   (J) JUMP TO SPECIFIED TIME STEP'                  M2090...
     3        /10X,'   (A) ABORT THIS PLOT')                             M2100...
  570 FORMAT (//'     INPUT TIME STEP ==> ')                              M2110...
  580 FORMAT (A)                                                          M2120...
  590 FORMAT (I4)                                                         M2130...
  595 WRITE (1,597)                                                       M2140...
      JFLAG=0                                                             M2150...
      REWIND (77)                                                         M2160...
      CALL QCHECK(IPLOT,ISTAT)                                            M2170...
      IF (IPLOT.EQ.0) RETURN                                              M2180...
      GOTO 200                                                            M2190...
  597 FORMAT (/10X,'-----------------------------------------'            M2200...
```

Program listing -- continued

```
     1        /10X,'     >>>>  END OF FILE ENCOUNTERED  <<<<'           M2210...
     2        /10X,'                                                 '  M2220...
     3        /10X,'  Do you want to re-read the printout file?'       M2230...
     4        /10X,'                  (Y/N?)'                         M2240...
     5        /10X,'-----------------------------------------')       M2250...
C                                                                      M2260...
  608 FORMAT (//15X,'This printout contains only')                     M2270...
  610 FORMAT (  15X,'STEADY-STATE CONCENTRATIONS')                     M2280...
  612 FORMAT (  15X,' STEADY-STATE TEMPERATURES')                      M2290...
  614 FORMAT (  15X,'  STEADY-STATE PRESSURES')                       M2300...
  616 FORMAT (  15X,'  STEADY-STATE VELOCITIES')                      M2310...
  620 FORMAT (  15X,'-------------------------'                        M2320...
     1         /10X,'(P) PLOT THE STEADY-STATE DATA'                  M2330...
     2         /10X,'(A) ABORT THIS PLOT'/)                           M2340...
C                                                                      M2350...
  900 RETURN                                                           M2360...
      END                                                              M2370...
```

Program listing -- continued

```
C     ***            S U B R O U T I N E   O U T D E V                N10.....
C     ***                      Version 1086S                          N20.....
C     *** Purpose:                                                    N30.....
C     ***    Selects graphic output device                            N40.....
C     ***    This subroutine is installation dependent. Output device N50.....
C     ***    options must be changed to accommodate available devices. N60.....
C     ***    Minimum requirement is a single device call such as:     N70.....
C     ***        SUBROUTINE OUTDEV                                    N80.....
C     ***        CALL TAB                                             N90.....
C     ***        RETURN                                               N100....
C     ***    See DISSPLA manuals for details of device options.       N110....
C     ***                                                            N120....
C                                                                    N130....
      SUBROUTINE OUTDEV(IDEV)                                        N140....
C                                                                    N150....
      WRITE(1,60)                                                    N160....
      CALL NCHECK(5,IDEV,ISTAT)                                      N170....
      GOTO (10,20,30,40,50) IDEV                                     N180....
C                                                                    N190....
   10 WRITE(1,64)                                                    N200....
      CALL TAB                                                       N220....
      GOTO 70                                                        N230....
C                                                                    N240....
   20 WRITE(1,62)                                                    N250....
      CALL HIPLOT (29,1,2)                                           N260....
      GOTO 70                                                        N270....
C                                                                    N280....
   30 WRITE(1,65)                                                    N290....
      CALL HIPLOT (29,1,2)                                           N300....
      GOTO 70                                                        N310....
C                                                                    N320....
   40 WRITE(1,66)                                                    N330....
      CALL TK41(4109)                                                N340....
      GOTO 70                                                        N350....
C                                                                    N360....
   50 CALL COMPRS                                                    N370....
C     GOTO 70                                                        N380....
C                                                                    N390....
   60 FORMAT(//10X,'     SELECT OUTPUT DEVICE'                       N400....
     1        /10X,'-----------------------------------'             N410....
     2        /10X,'(1) TAB 132/15-G GRAPHICS Terminal'              N420....
     3        /10X,'(2) Houston Instruments DMP-29'                  N430....
     4        /10X,'(3) Houston Instruments DMP-52'                  N440....
     5        /10X,'(4) Tektronix 4209'                              N450....
     6        /10X,'(5) Create a META file')                         N460....
C                                                                    N470....
   62 FORMAT(//'  *** HI DMP-29 SELECTED ***  ')                     N480....
   64 FORMAT(//'  *** TAB 132/15-G SELECTED ***  ')                  N490....
   65 FORMAT(//'  *** HI DMP-52 SELECTED ***  ')                     N500....
   66 FORMAT(//'  *** TEK 4209 SELECTED ***  ')                      N510....
   70 RETURN                                                        N520....
      END                                                           N530....
```

Program listing -- continued

```
C     ***          S U B R O U T I N E   K O N T U R                  010.....
C     ***                    Version 1086S                            020.....
C     *** Purpose:                                                    030.....
C     ***    Call appropriate DISSPLA routines to contour data        040.....
C                                                                     050.....
      SUBROUTINE KONTUR(X,Y,U,XYMAX,UGRID,UMAT,                       060.....
     1                  IXY,IN,LNUM)                                  070.....
      DOUBLE PRECISION X,Y,U,XYMAX                                    080.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                               090.....
      CHARACTER*60 LXNAME,LYNAME                                      0100....
      CHARACTER*6 LINE(5)                                             0110....
      CHARACTER*8 LABEL(2)                                            0120....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                 0130....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,            0140....
     1             YMIN,YINT,YMAX,                                    0150....
     2             IPLOT,NPLOT,IREAD,                                 0160....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                0170....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                 0180....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                 0190....
     2                 ZINCR,UBASE,UMULT                              0200....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP         0210....
      COMMON WORK(1000000)                                            0220....
      DIMENSION X(NN),Y(NN),U(NN),XYMAX(NE)                           0230....
      DIMENSION IN(NE,4),IXY(NE),LNUM(IXDIM*IYDIM)                    0240....
      DIMENSION UMAT(IXDIM,IYDIM),UGRID(IXDIM*IYDIM)                  0250....
      DATA LINE /'DOT','DASH','CHNDOT','CHNDSH','SOLID'/              0260....
      DATA LABEL /'LABELS','NOLABELS'/                                0270....
C                                                                     0280....
C.....Scale contour data to user selected units                       0290....
      IF (ISCAL.EQ.1) THEN                                            0300....
         DO 10 I=1,NN                                                 0310....
            U(I)= ABS(U(I) / UBASE * UMULT)                           0320....
   10    CONTINUE                                                     0330....
           END IF                                                     0340....
C                                                                     0350....
C.....Call finite-element interpolation routine to grid data          0360....
      IF (IGRID.EQ.2) THEN                                            0370....
         IJ=1                                                         0380....
         CALL GRIDR(X,Y,U,XYMAX,UGRID,IN,IXY,LNUM)                    0390....
         DO 150 J=1,IYDIM                                             0400....
         DO 150 I=1,IXDIM                                             0410....
            UMAT(I,J) = UGRID(IJ)                                     0420....
  150       IJ=IJ+1                                                   0430....
         GOTO 160                                                     0440....
      END IF                                                          0450....
C                                                                     0460....
C.....No gridding...load UMAT with raw data                           0470....
      IF (IGRID.EQ.3) THEN                                            0480....
         IJ=1                                                         0490....
         IF (NUMDIR.EQ.1) THEN                                        0500....
            DO 152 I=1,IXDIM                                          0510....
            DO 152 J=1,IYDIM                                          0520....
               UMAT(I,J) = SNGL(U(IJ))                                0530....
  152          IJ=IJ+1                                               0540....
         ELSE                                                         0550....
```

Program listing -- continued

```
            DO 155 J=1,IYDIM                                          0560....
            DO 155 I=1,IXDIM                                          0570....
               UMAT(I,J) = SNGL(U(IJ))                                0580....
  155          IJ=IJ+1                                                0590....
         END IF                                                       0600....
         GOTO 160                                                     0610....
      END IF                                                          0620....
C                                                                     0630....
C.....Grid data using DISSPLA routines                                0640....
      CALL BGNMAT (IXDIM,IYDIM)                                       0650....
      DO 157 IG=1,NN                                                  0660....
         USGL=SNGL(U(IG))                                             0670....
         XSGL=SNGL(X(IG))                                             0680....
         YSGL=SNGL(Y(IG))                                             0690....
  157    CALL GETMAT (XSGL,YSGL,USGL,1,0)                             0700....
      CALL ENDMAT (UMAT,0)                                            0710....
C                                                                     0720....
  160 CALL BCOMON (100000)                                            0730....
      CALL CONMIN (2.5)                                               0740....
      IF (IZIN.EQ.1) THEN                                             0750....
         CALL CONMAK (UMAT,IXDIM,IYDIM,'SCALE')                       0760....
      ELSE                                                            0770....
         CALL CONMAK (UMAT,IXDIM,IYDIM,ZINCR)                         0780....
      END IF                                                          0790....
      CALL CONLIN (0,LINE(MODE),LABEL(LBLFLG),ITHICK,5)               0800....
      CALL CONANG (90.)                                               0810....
C                                                                     0820....
      CALL CONTUR (1,LABEL(LBLFLG),'DRAW')                            0830....
      RETURN                                                          0840....
      END                                                             0850....
```

Program listing -- continued

```
C     ***              S U B R O U T I N E   G R I D R                P10.....
C     ***                       Version 1086S                         P20.....
C     *** Purpose:                                                    P30.....
C     ***    Grids irregular data using a finite-element interpolation. P40.....
C     ***    The interpolation routine calculates values at grid points P50.....
C     ***    using basis functions and numerical algorithms equivalent  P60.....
C     ***    to those used in SUTRA methodology. The values at the grid P70.....
C     ***    points obtained from this routine are exact. Grid location P80.....
C     ***    data is stored in the setup file.                          P90.....
C                                                                       P100....
      SUBROUTINE GRIDR(X,Y,U,XYMAX,UGRID,IN,IXY,LNUM)                   P110....
      DOUBLE PRECISION X(NN),Y(NN),U(NN),XYMAX(NE)                      P120....
      DOUBLE PRECISION A1,A2,B1,B2,RINV1,RINV2,RSQ1,RSQ2,TANGLE,        P130....
     1                 THETA,TWOPI,PI,XK,YK                            P140....
      DOUBLE PRECISION XLK(4),YLK(4)                                    P150....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                                 P160....
      CHARACTER*60 LXNAME,LYNAME                                        P170....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                   P180....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,              P190....
     1             YMIN,YINT,YMAX,                                      P200....
     2             IPLOT,NPLOT,IREAD,                                   P210....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                  P220....
      COMMON /CONTOUR/ IGRID,ITYPE,ISAVE,MODE,LBLFLG,                   P230....
     1                 ITHICK,IDIR,IZIN,ISCAL,NUMDIR,                   P240....
     2                 ZINCR,UBASE,UMULT                                P250....
      DIMENSION IN(NE,4),IXY(NE)                                        P260....
      DIMENSION UGRID(IXDIM*IYDIM),LNUM(IXDIM*IYDIM)                    P270....
      DIMENSION KM(12)                                                  P280....
      DATA KM /2,3,4,1,3,4,1,2,4,1,2,3/                                 P290....
      DATA PI /3.141592654/                                             P300....
      DATA TWOPI /6.283185308/                                          P310....
      DATA TOL /.001/,ITRMAX /50/                                       P320....
C                                                                       P330....
C.....Finite-element interpolation routine starts in statement 700      P340....
C.....Grid points must first be generated and their coordinates         P350....
C.....located in the finite-element mesh.                               P360....
C                                                                       P370....
      LFLAG = 0                                                         P380....
C.....Set grid dimensions                                               P390....
      NEX=IXDIM-1                                                       P400....
      NEY=IYDIM-1                                                       P410....
      DXL=(XMAX-XMIN)/FLOAT(NEX)                                        P420....
      DYL=(YMAX-YMIN)/FLOAT(NEY)                                        P430....
      IF (ITYPE.EQ.1.or.ne.eq.1) GOTO 200                               P440....
C                                                                       P450....
C.....Array XYMAX contains maximum node coordinate of each element      P460....
C.....Select direction to search with least number of grid points       P470....
      IF (NEX.GT.NEY) THEN                                              P480....
         IDIR=1                                                         P490....
         DO 50 I=1,NE                                                   P500....
   50       XYMAX(I)=DMAX1(X(IN(I,1)),X(IN(I,2)),X(IN(I,3)),X(IN(I,4))) P510....
         GOTO 70                                                        P520....
      END IF                                                            P530....
      IDIR=0                                                            P540....
      DO 60 I=1,NE                                                      P550....
```

Program listing -- continued

```
   60    XYMAX(I)=DMAX1(Y(IN(I,1)),Y(IN(I,2)),Y(IN(I,3)),Y(IN(I,4)))    P560....
C                                                                       P570....
C.....Sort array XYMAX into ascending numerical order                   P580....
   70 DO 100 J=1,NE                                                     P590....
  100    IXY(J)=J                                                       P600....
      L=NE/2+1                                                          P610....
      IR=NE                                                             P620....
  110 CONTINUE                                                          P630....
      IF (L.GT.1) THEN                                                  P640....
         L=L-1                                                          P650....
         INDXT=IXY(L)                                                   P660....
         Q=XYMAX(INDXT)                                                 P670....
      ELSE                                                              P680....
         INDXT=IXY(IR)                                                  P690....
         Q=XYMAX(INDXT)                                                 P700....
         IXY(IR)=IXY(1)                                                 P710....
         IR=IR-1                                                        P720....
         IF (IR.EQ. 1) THEN                                             P730....
            IXY(1)=INDXT                                                P740....
            GOTO 200                                                    P750....
         END IF                                                         P760....
      END IF                                                            P770....
      I=L                                                               P780....
      J=L+L                                                             P790....
  120 IF (J.LE.IR) THEN                                                 P800....
         IF (J.LT.IR) THEN                                              P810....
            IF (XYMAX(IXY(J)).LT.XYMAX(IXY(J+1))) J=J+1                 P820....
         END IF                                                         P830....
         IF (Q.LT.XYMAX(IXY(J))) THEN                                   P840....
            IXY(I)=IXY(J)                                               P850....
            I=J                                                         P860....
            J=J+J                                                       P870....
         ELSE                                                           P880....
            J=IR+1                                                      P890....
         END IF                                                         P900....
      GOTO 120                                                          P910....
      END IF                                                            P920....
      IXY(I)=INDXT                                                      P930....
      GOTO 110                                                          P940....
C                                                                       P950....
C                                                                       P960....
C.....Locate each grid point in the finite-element mesh                 P970....
  200 NP=0                                                              P980....
      DO 900 NY=1,IYDIM                                                 P990....
      DO 900 NX=1,IXDIM                                                 P1000...
         NP=NP+1                                                        P1010...
         YK=(FLOAT(NY-1)*DYL) + YMIN                                    P1020...
         XK=(FLOAT(NX-1)*DXL) + XMIN                                    P1030...
      IF (ITYPE.EQ.1.or.ne.eq.1) GOTO 700                               P1040...
C.....Begin search...skip over elements if grid point coordinate is     P1050...
C.....    greater than maximum coordinate of element                    P1060...
      DO 580 I=1,NE                                                     P1070...
         IF (IDIR.EQ.1.AND.XK.GT.XYMAX(IXY(I))) GOTO 580                P1080...
         IF (IDIR.EQ.0.AND.YK.GT.XYMAX(IXY(I))) GOTO 580                P1090...
C                                                                       P1100...
```

Program listing -- continued

```
C.....After narrowing search, determine if grid point is within element.P1110...
C.....A 'point in polygon' problem.  This routine calculates the four   P1120...
C.....angles between adjacent line segments between the grid point and  P1130...
C.....and the four element nodes.  If the sum of the angles is equal to P1140...
C.....360 degrees, then the grid point lies within the element.         P1150...
C                                                                       P1160...
         TANGLE = 0.                                                    P1170...
C.....Generate four line segments                                       P1180...
         DO 520 N=1,4                                                   P1190...
            XLK(N) = X(IN(IXY(I),N)) - XK                               P1200...
  520       YLK(N) = Y(IN(IXY(I),N)) - YK                               P1210...
C.....Calculate angles between line segments by direction cosines       P1220...
         DO 540 M=1,4                                                   P1230...
            RSQ1 = DSQRT(XLK(M)*XLK(M)+YLK(M)*YLK(M))                   P1240...
            RSQ2 = DSQRT(XLK(KM(M))*XLK(KM(M))+YLK(KM(M))*YLK(KM(M)))   P1250...
C.....If zero segment length, then grid point coincides with node       P1260...
            IF (RSQ1 .LT. 1.D-10) GOTO 590                              P1270...
            IF (RSQ2 .LT. 1.D-10) GOTO 590                              P1280...
C.....Calculate coefficients of normalized, implicit equations          P1290...
            RINV1=1./RSQ1                                               P1300...
            RINV2=1./RSQ2                                               P1310...
            A1 = -YLK(M)*RINV1                                          P1320...
            A2 = -YLK(KM(M))*RINV2                                      P1330...
            B1 =  XLK(M)*RINV1                                          P1340...
            B2 =  XLK(KM(M))*RINV2                                      P1350...
C.....The angle between the line segments, THETA, is calculated by:     P1360...
            THETA=DACOS(DMIN1(1.D0,DMAX1(-1.D0,A1*A2 + B1*B2)))         P1370...
C.....  (where the expression for the cosine argument corrects small    P1380...
C.....   numerical rounding errors)                                     P1390...
C                                                                       P1400...
C.....If THETA = 180 degrees, then grid point lies on element side      P1410...
            IF (DABS(THETA-PI).LT.1.D-3) GOTO 590                       P1420...
C.....Sum the angles                                                    P1430...
            TANGLE = TANGLE + THETA                                     P1440...
C.....If the sum = 360 degrees, then the grid point lies in element     P1450...
            IF (DABS(TANGLE-TWOPI).LT.1.D-3) GOTO 590                   P1460...
  540    CONTINUE                                                       P1470...
  580 CONTINUE                                                          P1480...
C                                                                       P1490...
C.....Save location of grid point for future plots                      P1500...
  590 IF(I.GT.NE) THEN                                                  P1510...
        LNUM(NP) = 0                                                    P1520...
      ELSE                                                              P1530...
        LNUM(NP) = IXY(I)                                               P1540...
      END IF                                                            P1550...
C                                                                       P1560...
C............Main interpolation routine.....                           P1570...
C.....A value for U is evaluated at each grid point.  The global        P1580...
C.....coordinates of the grid point are transformed to local            P1590...
C.....coordinates using equations 6.3 and 6.4. Equations 6.6 and        P1600...
C.....6.7 are solved using a Newton-Raphson iterative routine.          P1610...
C                                                                       P1620...
  700 N = LNUM(NP)                                                      P1630...
      IF (NE.EQ.1) N = 1                                                P1640...
      IF (N.EQ.0) THEN                                                  P1650...
```

Program listing -- continued

```
         UGRID(NP) = 0.0                                                P1660...
         GOTO 900                                                       P1670...
      END IF                                                            P1680...
C                                                                       P1690...
      X1=X(IN(N,1))                                                     P1700...
      X2=X(IN(N,2))                                                     P1710...
      X3=X(IN(N,3))                                                     P1720...
      X4=X(IN(N,4))                                                     P1730...
      Y1=Y(IN(N,1))                                                     P1740...
      Y2=Y(IN(N,2))                                                     P1750...
      Y3=Y(IN(N,3))                                                     P1760...
      Y4=Y(IN(N,4))                                                     P1770...
C.....Calculate coefficients for F10 and F20                            P1780...
      AX=+X1+X2+X3+X4                                                   P1790...
      BX=-X1+X2+X3-X4                                                   P1800...
      CX=-X1-X2+X3+X4                                                   P1810...
      DX=+X1-X2+X3-X4                                                   P1820...
      AY=+Y1+Y2+Y3+Y4                                                   P1830...
      BY=-Y1+Y2+Y3-Y4                                                   P1840...
      CY=-Y1-Y2+Y3+Y4                                                   P1850...
      DY=+Y1-Y2+Y3-Y4                                                   P1860...
      ITER=0                                                            P1870...
C.....Initial guess of zero for XSI and ETA                             P1880...
      XSI=0.                                                            P1890...
      ETA=0.                                                            P1900...
C.....Start of iteration loop                                           P1910...
  800 XSI0=XSI                                                          P1920...
      ETA0=ETA                                                          P1930...
      ITER=ITER + 1                                                     P1940...
      F10=AX-4.*XK+BX*XSI0+CX*ETA0+DX*XSI0*ETA0                         P1950...
      F20=AY-4.*YK+BY*XSI0+CY*ETA0+DY*XSI0*ETA0                         P1960...
      FP11=BX+DX*ETA0                                                   P1970...
      FP12=CX+DX*ETA0                                                   P1980...
      FP21=BY+DY*XSI0                                                   P1990...
      FP22=CY+DY*XSI0                                                   P2000...
      DET=FP11*FP22-FP12*FP21                                           P2010...
      DELXSI=(-F10*FP22+F20*FP12)/DET                                   P2020...
      DELETA=(-F20*FP11+F10*FP21)/DET                                   P2030...
      XSI=XSI0+DELXSI                                                   P2040...
      ETA=ETA0+DELETA                                                   P2050...
      IF (ITER.GT.ITRMAX) GOTO 1000                                     P2060...
C.....Continue iterating if change in XSI or ETA > .001                 P2070...
      IF (ABS(DELXSI).GT.TOL.OR.ABS(DELETA).GT.TOL) GOTO 800            P2080...
C.....Basis functions for corner node are defined as:                   P2090...
      PHI1=.25*(1.-XSI)*(1.-ETA)                                        P2100...
      PHI2=.25*(1.+XSI)*(1.-ETA)                                        P2110...
      PHI3=.25*(1.+XSI)*(1.+ETA)                                        P2120...
      PHI4=.25*(1.-XSI)*(1.+ETA)                                        P2130...
C.....The value of U is evaluated using equation 6.8                   P2140...
      UGRID(NP) = U(IN(N,1))*PHI1+U(IN(N,2))*PHI2+                      P2150...
     1            U(IN(N,3))*PHI3+U(IN(N,4))*PHI4                       P2160...
  900 CONTINUE                                                          P2170...
C                                                                       P2180...
  999 ITYPE=1                                                           P2190...
      RETURN                                                            P2200...
```

Program listing -- continued

```
1000 WRITE (1,1100) NP,N,XSI,ETA                                          P2210...
1100 FORMAT (///5X,'GRID POINT',I5,'DID NOT CONVERGE IN ELEMENT',I5//     P2220...
    1        5X,'XSI= ',1PE15.7,5X,'ETA= ',1PE15.7)                       P2230...
     STOP                                                                 P2240...
     END                                                                  P2250...
```

Program listing -- continued

```
C     ***          S U B R O U T I N E   V E C P L T                  Q10.....
C     ***                    Version 1086S                            Q20.....
C     *** Purpose:                                                    Q30.....
C     ***    Calculates and scales velocity vectors.                  Q40.....
C     ***    Plots vectors using DISSPLA routines.                    Q50.....
C                                                                     Q60.....
      SUBROUTINE VECPLT(X,Y,VMAG,VANG,IN)                           Q70.....
      DOUBLE PRECISION X,Y,VMAG,VANG                                Q80.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                             Q90.....
      CHARACTER*60 LXNAME,LYNAME                                    Q100....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                               Q110....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,          Q120....
     1             YMIN,YINT,YMAX,                                  Q130....
     2             IPLOT,NPLOT,IREAD,                               Q140....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME              Q150....
      COMMON /VPLOT/ VLSCL,VPSCL,VASCL,ILSCL,IASCL,IVEC,ISKIP       Q160....
      DIMENSION X(NN),Y(NN),IN(NE,4)                                Q170....
      DIMENSION VMAG(NE),VANG(NE)                                   Q180....
C                                                                   Q190....
      VMAX=0.0                                                      Q200....
      VMIN=1.E9                                                     Q210....
C.....Calculate minimum and maximum vector magnitudes               Q220....
      DO 300 I=1,NE                                                 Q230....
         IF (VMAG(I).LT.VMIN) VMIN=VMAG(I)                          Q240....
         IF (VMAG(I).GT.VMAX) VMAX=VMAG(I)                          Q250....
  300 CONTINUE                                                      Q260....
C.....Scale to plotting device                                      Q270....
      PSCALX=XAXIS/(XMAX-XMIN)                                      Q280....
      PSCALY=YAXIS/(YMAX-YMIN)                                      Q290....
C.....VASCL controls vector angle scaling to distorted page         Q300....
      VASCL=PSCALY/PSCALX                                           Q310....
      IF (IASCL.EQ.0) VASCL=1.0                                     Q320....
C                                                                   Q330....
      DO 400 I = 1,NE,ISKIP                                         Q340....
         VMAG4=SNGL(VMAG(I))                                        Q350....
         IF (VMAG4/VMAX.LT.VLSCL.OR.VMAG4.EQ.0.0) GOTO 400          Q360....
         XSUM=0.                                                    Q370....
         YSUM=0.                                                    Q380....
C.....Calculate element centroid                                   Q390....
         DO 450 J=1,4                                               Q400....
            XSUM=XSUM+X(IN(I,J))                                    Q410....
  450       YSUM=YSUM+Y(IN(I,J))                                    Q420....
         XCENT=(XSUM/4.-XMIN)*PSCALX                                Q430....
         YCENT=(YSUM/4.-YMIN)*PSCALY                                Q440....
         XMAG = VMAG4 * COS(VANG(I) * 0.0174533)                    Q450....
         YMAG = VMAG4 * SIN(VANG(I) * 0.0174533)                    Q460....
         YMAGN = YMAG * VASCL                                       Q470....
         VANGN = ATAN2(YMAGN,XMAG)                                  Q480....
C.....Scale vector to logarithm of magnitude                        Q490....
         IF (ILSCL.EQ.2) THEN                                       Q500....
            RTLOG=ALOG10(VMAG4/VMAX)                                Q510....
            VRLOG=1/(1-RTLOG)                                       Q520....
            VMAG4=VRLOG*VPSCL                                       Q530....
         ELSE                                                       Q540....
C.....Scale vector to linear multiples of magnitude                 Q550....
```

Program listing -- continued

```
            VMAG4=VMAG4/VMAX*VPSCL                                    Q560....
         END IF                                                       Q570....
C                                                                     Q580....
         XMAGF = VMAG4 * COS(VANGN)                                   Q590....
         YMAGF = VMAG4 * SIN(VANGN)                                   Q600....
         XEND = XCENT + XMAGF                                         Q610....
         YEND = YCENT + YMAGF                                         Q620....
         CALL VECTOR (XCENT,YCENT,XEND,YEND,IVEC)                     Q630....
 400  CONTINUE                                                        Q640....
C                                                                     Q650....
      RETURN                                                          Q660....
      END                                                             Q670....
```

Program listing -- continued

```
C     ***          S U B R O U T I N E   M E S H P                    R10.....
C     ***                    Version 1086S                            R20.....
C     *** Purpose:                                                    R30.....
C     ***    Draws a finite-element mesh or the perimeter of the      R40.....
C     ***    mesh using DISSPLA routines.                             R50.....
C                                                                     R60.....
      SUBROUTINE MESHP(X,Y,IN,NODEP)                                  R70.....
      DOUBLE PRECISION X,Y                                            R80.....
      CHARACTER*4 PLOTYPE,CONTYPE,CONTX                               R90.....
      CHARACTER*60 LXNAME,LYNAME                                      R100....
      COMMON /DIMS/ NN,NE,IXDIM,IYDIM                                 R110....
      COMMON /ALL/ XAXIS,YAXIS,PAGEX,PAGEY,XMIN,XINT,XMAX,            R120....
     1             YMIN,YINT,YMAX,                                    R130....
     2             IPLOT,NPLOT,IREAD,                                 R140....
     3             PLOTYPE,CONTYPE,CONTX,LXNAME,LYNAME                R150....
      COMMON /MESH/ ISIDE,NCOUNT                                      R160....
      DIMENSION X(NN),Y(NN)                                           R170....
      DIMENSION IN(NE,4),NODEP(500)                                   R180....
      DIMENSION KN(5)                                                 R190....
      DATA KN /1,2,3,4,1/                                             R200....
C                                                                     R210....
      KOUNTA=0                                                        R220....
      NTEMP=1                                                         R230....
C                                                                     R240....
      CALL XNAME (' ',0)                                              R250....
      CALL YNAME (' ',0)                                              R260....
      CALL GRAF (XMIN,XINT,XMAX,YMIN,YINT,YMAX)                       R270....
C                                                                     R280....
C.....ISIDE controls drawing of common element sides                  R290....
      IF (ISIDE.EQ.3.AND.NCOUNT.GT.1) THEN                            R300....
         INDX=NCOUNT                                                  R310....
         IL=1                                                         R320....
         NSKIP=2                                                      R330....
      ELSE                                                            R340....
         INDX=NE                                                      R350....
         IL=4                                                         R360....
         NSKIP=1                                                      R370....
      END IF                                                          R380....
      DO 300 L=1,INDX,NSKIP                                           R390....
      DO 300 J =1,IL                                                  R400....
C.....Use previously saved perimeter nodes                            R410....
         IF (ISIDE.EQ.3.AND.NCOUNT.GT.1) THEN                         R420....
            NODE1=NODEP(L)                                            R430....
            NODE2=NODEP(L+1)                                          R440....
            GOTO 275                                                  R450....
         END IF                                                       R460....
C.....Counter for node pair to plot                                   R470....
         KOUNTA=KOUNTA+1                                              R480....
C.....ISIDE=3 plots only perimeter nodes...set counter to NE*4, the   R490....
C.....number of sides in the mesh to check ALL sides for duplication. R500....
C.....Only perimeter sides are NOT duplicated.                        R510....
         IF (ISIDE.EQ.3) KOUNTA=NE*4                                  R520....
         NODE1 = IN(L,KN(J))                                          R530....
         NODE2 = IN(L,KN(J+1))                                        R540....
C.....ISIDE=1 draws all sides of all elements                         R550....
```

Program listing -- continued

```
         IF (ISIDE.EQ.1) GOTO 275                                          R560....
C.....Re-read node pairs and check for duplicates                          R570....
         KOUNTB=0                                                          R580....
         DO 250 N=1,NE                                                     R590....
         DO 250 K=1,4                                                      R600....
C.....Counter for node pair to check against plotting pair                 R610....
            KOUNTB=KOUNTB+1                                                R620....
C                                                                          R630....
C.....Check for duplicates up to node pair, KOUNTA                         R640....
C.....  If KOUNTA = NE*4, draw only non-duplicated sides, ie perimeter     R650....
C.....  If KOUNTA = current plotting pair, draw if not a duplicate         R660....
C                                                                          R670....
            IF (KOUNTB.GT.KOUNTA) GOTO 275                                 R680....
            NODEA = IN(N,KN(K))                                            R690....
            NODEB = IN(N,KN(K+1))                                          R700....
C.....Check for previously plotted side                                    R710....
            IF (NODEA.EQ.NODE2.AND.NODEB.EQ.NODE1) GOTO 300                R720....
  250    CONTINUE                                                          R730....
C                                                                          R740....
  275    X1=SNGL(X(NODE1))                                                 R750....
         Y1=SNGL(Y(NODE1))                                                 R760....
         X2=SNGL(X(NODE2))                                                 R770....
         Y2=SNGL(Y(NODE2))                                                 R780....
C                                                                          R790....
         CALL RLVEC(X1,Y1,X2,Y2,0)                                         R800....
         IF (ISIDE.EQ.3.AND.NCOUNT.EQ.1) THEN                              R810....
            NODEP(NTEMP)=NODE1                                             R820....
            NODEP(NTEMP+1)=NODE2                                           R830....
            NTEMP=NTEMP+2                                                  R840....
         END IF                                                            R850....
C                                                                          R860....
  300 CONTINUE                                                             R870....
      IF (ISIDE.EQ.3.AND.NCOUNT.EQ.1) NCOUNT=NTEMP-1                       R880....
C                                                                          R890....
      RETURN                                                               R900....
      END                                                                  R910....
```

Program listing -- continued

```
C    ***          S U B R O U T I N E   S K I P                    S10.....
C    ***                  Version 1086S                            S20.....
C    *** Purpose:                                                  S30.....
C    ***    Read dummy input to skip one line of input data        S40.....
C                                                                  S50.....
      SUBROUTINE SKIP(IUNIT)                                       S60.....
      CHARACTER*1 DUMMY                                            S70.....
C                                                                  S80.....
      READ(IUNIT,99)   DUMMY                                       S90.....
  99  FORMAT(A1)                                                   S100....
C                                                                  S110....
      RETURN                                                       S120....
      END                                                          S130....
```

Program listing -- continued

```
C     ***           S U B R O U T I N E   Q C H E C K                  T10.....
C     ***                  Version 1086S                               T20.....
C     *** Purpose:                                                     T30.....
C     ***    Reads and checks for valid response to a Y/N? query       T40.....
C     ***    Passes ICODE back to calling routine:                     T50.....
C     ***             0= NO      1= YES                                T60.....
C                                                                      T70.....
      SUBROUTINE QCHECK(ICODE,ISTAT)                                   T80.....
      CHARACTER RSPNSE                                                 T90.....
      ISTAT=0                                                          T100....
C                                                                      T110....
  100 READ (1,150,ERR=200,IOSTAT=ISTAT) RSPNSE                         T120....
      IF (RSPNSE.EQ.'Y'.OR.RSPNSE.EQ.'y') THEN                         T130....
         ICODE=1                                                       T140....
      ELSE IF (RSPNSE.EQ.'N'.OR.RSPNSE.EQ.'n') THEN                    T150....
         ICODE=0                                                       T160....
      ELSE                                                             T170....
         WRITE (1,110)                                                 T180....
         GOTO 100                                                      T190....
      END IF                                                           T200....
C                                                                      T210....
  110 FORMAT (/' ENTER  <Y> or <N> ONLY')                              T220....
  150 FORMAT (A)                                                       T230....
  200 RETURN                                                           T240....
      END                                                              T250....
```

Program listing -- continued

```
C     ***           S U B R O U T I N E   N C H E C K                  U10.....
C     ***                      Version 1086S                           U20.....
C     *** Purpose:                                                     U30.....
C     ***    Reads and checks for valid response to numbered menu      U40.....
C     ***    Passes the integer option IRSPN back to calling routine   U50.....
C                                                                      U60.....
      SUBROUTINE NCHECK(NNUM,IRSPN,ISTAT)                              U70.....
      CHARACTER*2 NUMBER(20),REPLY                                     U80.....
      DATA NUMBER /'1','2','3','4','5','6','7','8','9','10',          U90.....
     1    '11','12','13','14','15','16','17','18','19','20'/          U100....
C                                                                      U110....
      ISTAT=0                                                          U120....
C                                                                      U130....
   10 READ (1,210,ERR=200,IOSTAT=ISTAT) REPLY                          U140....
      IF (REPLY.EQ.'M'.OR.REPLY.EQ.'m') THEN                           U150....
         IRSPN=0                                                       U160....
         GOTO 300                                                      U170....
      END IF                                                           U180....
C                                                                      U190....
      IF (REPLY.EQ.'X'.OR.REPLY.EQ.'x') THEN                           U200....
         IRSPN=99                                                      U210....
         GOTO 300                                                      U220....
      END IF                                                           U230....
C                                                                      U240....
      DO 50 I=1,NNUM                                                   U250....
      IF (REPLY.EQ.NUMBER(I)) THEN                                     U260....
         IRSPN=I                                                       U270....
         GOTO 300                                                      U280....
      END IF                                                           U290....
   50 CONTINUE                                                         U300....
C                                                                      U310....
  200 WRITE (1,220)                                                    U320....
      GOTO 10                                                          U330....
C                                                                      U340....
  210 FORMAT (A)                                                       U350....
  220 FORMAT (/10X,'>>> INVALID RESPONSE- ENTER NUMBER OF OPTION <<<'  U360....
     1        /10X,'>>>         ( X = exit    M = menu )         <<<') U370....
C     .                                                                U380....
  300 RETURN                                                           U390....
      END                                                              U400....
```