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MODVIEW VERSION 1.0

A GRAPHICAL-KERNEL-SYSTEM PROGRAM
FOR EVALUATING MODFLOW DATA

by

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1994
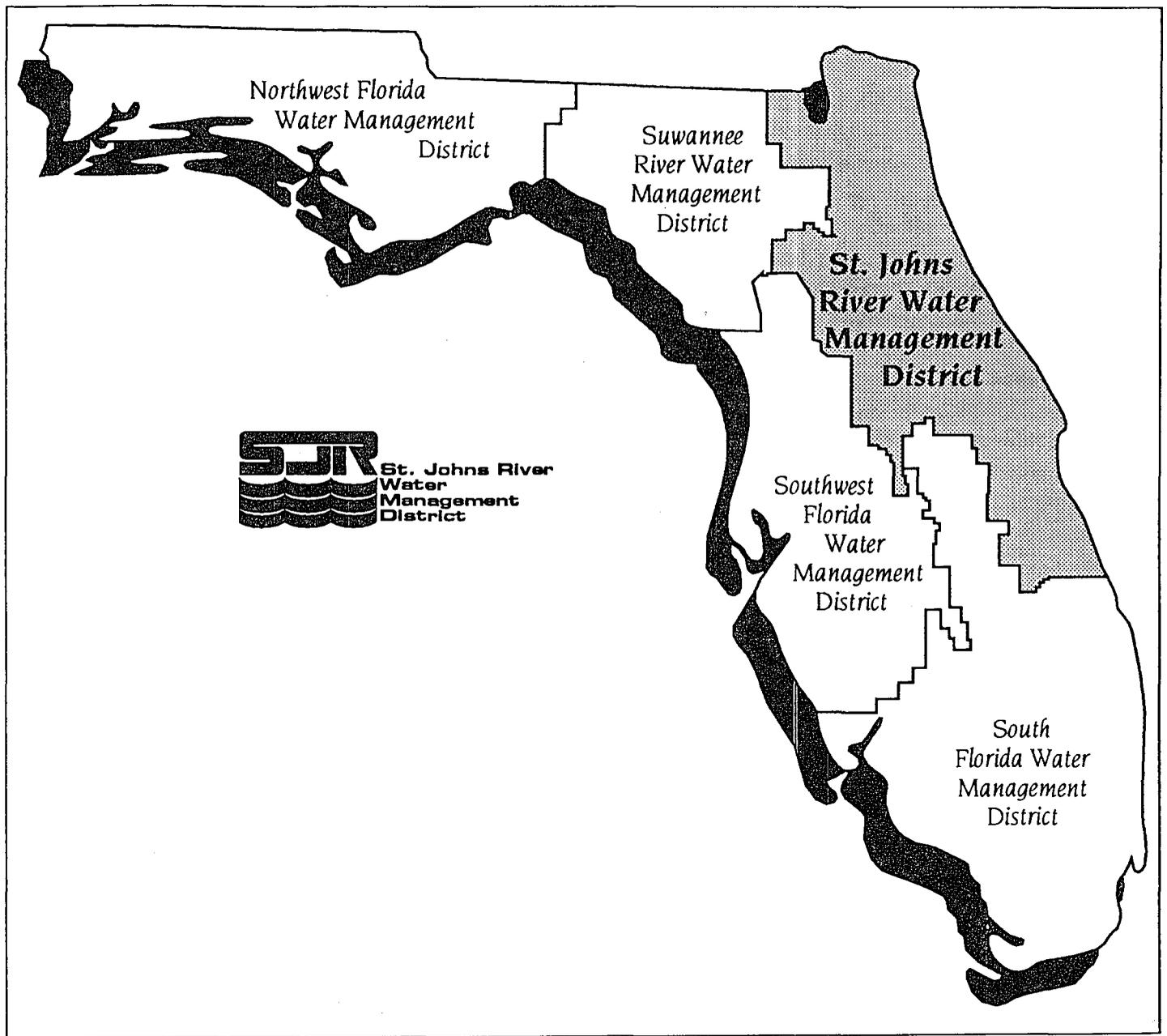
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EXECUTIVE SUMMARY

MODVIEW Version 1.0 is a Graphical-Kernel-System program that enables datasets arranged in the format of a two-dimensional array (i.e., sets of related numbers arranged in a format of rows and columns) to be viewed as colored patterns of numerical ranges. The St. Johns River Water Management District extensively uses the U.S. Geological Survey model MODFLOW (a ground water flow model) in performing ground water studies. MODFLOW input and output data files consist largely of two-dimensional arrays. These types of arrays are used in MODFLOW to represent spatially distributed values of hydraulic parameters such as transmissivity, leakance, and hydraulic head. MODVIEW is intended primarily to provide a convenient means of viewing MODFLOW datasets and thus to make calibrating and evaluating MODFLOW ground water flow models more efficient.

MODVIEW screen output consists of three types of displays: (1) a primary display, (2) subarea displays, and (3) zoom-reference displays. The primary display shows the entire model grid. Subarea displays show enlargements of specified subareas of the model grid. Zoom-reference displays show the position of a zoomed subarea with respect to the entire model grid.

MODVIEW will run on IBM-compatible personal computers equipped with EGA, VGA, or SVGA color graphics cards and color monitors. Hard-copy plots of MODVIEW output can be produced with the use of screen-capture programs such as Pizzaz Plus. Screen-capture programs enable MODVIEW output to be produced in black and white or in color. Output can be printed on dot-matrix, laser, or color printers.

CONTENTS

FIGURES

INTRODUCTION

MODVIEW Version 1.0 is a Graphical-Kernel-System program that enables datasets arranged in the format of a two-dimensional array to be viewed as colored patterns of numerical ranges. MODVIEW is intended primarily to provide a convenient means of viewing MODFLOW (McDonald and Harbaugh 1988) input and output datasets and thus to make calibrating and evaluating MODFLOW ground water flow models more efficient. MODVIEW is particularly useful for viewing distributions of aquifer and confining-unit properties that in many cases do not lend well to contouring. Examples of such distributions are leakance and transmissivity distributions (Figure 1). Other types of datasets that are well suited for viewing with MODVIEW include distributions of simulated hydraulic head, hydraulic-head residuals, drawdowns, well withdrawal rates, and recharge/discharge rates.

MODVIEW displays a given dataset by determining the range into which each data value falls and then filling the corresponding cell of the model finite-difference grid with a color that has been specified to represent the determined range. MODVIEW then superimposes the model finite-difference grid onto the resulting patterns of ranges, labels the finite-difference grid with row and column numbers, and displays the specified ranges and the corresponding representative colors in an accompanying legend. It can enlarge (zoom) specified subregions of a finite-difference grid for detailed viewing to better accommodate finite-difference grids that consist of relatively large numbers of rows and columns. Hard copies of MODVIEW output can be produced through the use of screen-capture programs such as Pizzaz Plus (Application Techniques 1990). Applications of MODVIEW need not be limited to MODFLOW datasets, as MODVIEW can be used to view any dataset that can be arranged in the format of a two-dimensional array.
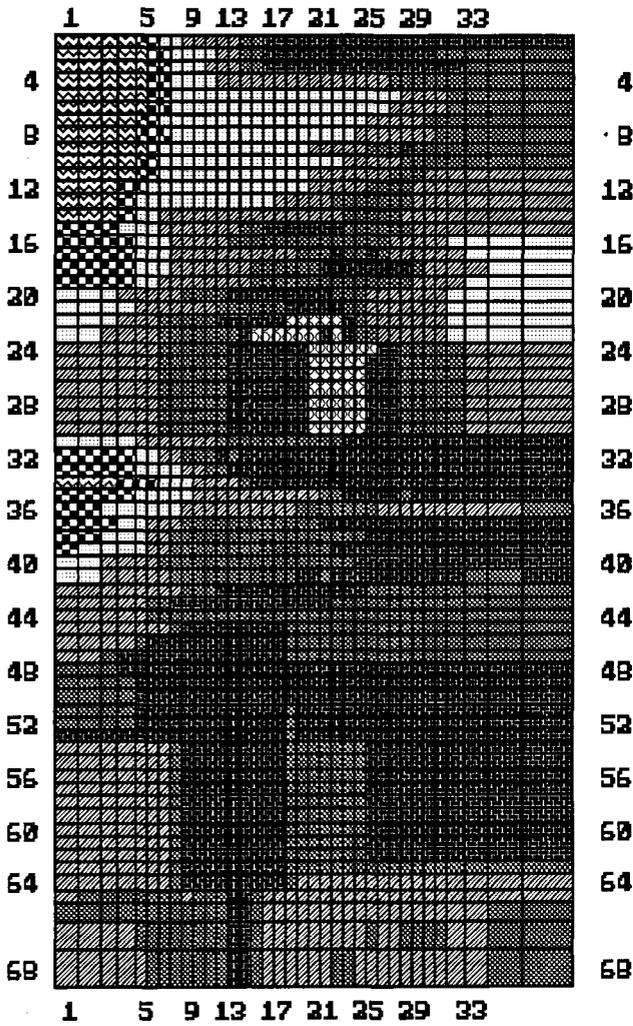
Sample plot of a
transmissivity array

(feet squared per day)

Figure 1.   MODVIEW representation of a MODFLOW transmissivity array

GUIDE FOR USE

DATA INPUT FILES

MODVIEW data input files consist of three general sections: (1) a statement of the number of rows and columns of the model finite-difference grid to be viewed, followed by (2) statements of the widths of the rows and columns of the model finite-difference grid, followed by (3) a statement of the array of data values to viewed.

Format of Data Input Files

MODVIEW data input files are free-format ASCII files (Figure 2). Data are stated according to the following order:

1. NROWS NCOLS
2. YDELT(1) . . . YDELT(NROWS)
3. XDELT(1) . . . XDELT(NCOLS)
4. A(1,1) . . . . A(1,NCOLS)

      .   .

      .   .

      .   .

    A(NROWS,1) . . . . A(NROWS,NCOLS)

NROWS Number of rows of the model finite-difference grid

NCOLS Number of columns of the model finite-difference grid

YDELT Widths of rows of the model finite-difference grid

XDELT Widths of columns of the model finite-difference grid

A   Array of data to be viewed

```
   File Contents                          Explanations

6 5                                       Number of rows, number of columns
5.0 4.0 3.0 4.0 5.0 2.0                   Widths of rows
4.0 3.0 5.0 3.0 2.0                       Widths of columns
1.0 -2.0 -5.5 -10.0 -7.0                  Row 1 of array of data
1.5 0.0 -3.0 -7.0 -10.0                   Row 2 of array of data
2.5 3.0 1.0 -1.5 -5.0                     Row 3 of array of data
999.0 4.0 3.0 2.0 0.0                     Row 4 of array of data
999.0 999.0 2.0 1.0 0.0                   Row 5 of array of data
999.0 999.0 999.0 3.0 -1.0               Row 6 of array of data

Note:  999.0s in rows 4, 5, and 6 indicate inactive cells.
```

Figure 2.   Sample input data file

Additional Information Concerning Data Input Files

Each member of an "A" array must be separated by a blank space from the one preceding it and the one following it (Figure 2). The negative sign of a negative data value is part of the value. Therefore, a blank space must separate negative signs from the preceding data value.

Lines of data cannot be extended beyond column 80. They can, however, be wrapped around to as many succeeding lines of the input file as necessary.

DEFINING NUMERICAL RANGES

General Description

MODVIEW represents arrays of data as colored patterns of numerical ranges. Therefore, numerical ranges must be defined for each A array prior to viewing. A numerical range is defined by two numbers, a low end and a high end. The low end of each numerical range is identical to the high end of the preceding numerical range. For example, a set of five numerical ranges could be defined as follows:

	Low End	High End
Range 1	-10	-5
Range 2	-5	0
Range 3	0	5
Range 4	5	10
Range 5	10	15

Once the numerical ranges are defined, MODVIEW assigns every member of the A array to one of the ranges, providing every member of the A array falls within one of the ranges. To be assigned to a given numerical range, a member of the A array must be greater than or equal to the low end of the range and

less than the high end. An exception occurs only when the maximum value of an array of data and the high end of the last numerical range are identical. In such a case, the maximum value of the A array is included in the last range. A maximum of 15 numerical ranges can be defined.

Every member of the A array must be assigned to one of the defined numerical ranges, except members representing inactive grid cells, which are described later. Therefore, if members of an A array are less than the low end of the first numerical range or greater than the high end of the last numerical range, a run-time error will result. To help prevent this, MODVIEW determines and reports the minimum and maximum values of each A array prior to prompting the user to define the numerical ranges.

For an array of residuals of hydraulic head in which the minimum data value is -5.2 feet (ft) and the maximum data value is 10.3 ft, the value of -5.2 ft would be assigned to the first numerical range in the set of numerical ranges defined above and the value of 10.3 ft would be assigned to the fifth numerical range. If the minimum value were -5.0 ft instead of -5.2 ft, however, this value would be assigned to the second numerical range and no values would be assigned to the first numerical range. If the maximum value of the dataset were 15.0 ft instead of 10.3 ft, it would still be assigned to the fifth numerical range, however.

A run-time error would result if the minimum data value were a number less than -10.0 ft or if the maximum data value were a number greater than 15.0 ft because such values would not fall into one of the defined numerical ranges. Redefinition of the first and/or fifth numerical range would be required in such a case.

Options for Defining Numerical Ranges

The numerical ranges and corresponding colors can be defined by three different methods: (1) automatic definition by MODVIEW, (2) interactive definition by the user, or (3) external definition by the user through the use of control input files. MODVIEW

prompts the user to choose one of these options after reporting the minimum and maximum values of the A array.

Automatic Definition of Numerical Ranges. To choose automatic definition, the user should select option 1 in response to the prompt to select a method for defining the numerical ranges and assigning colors. MODVIEW then prompts the user to indicate whether or not titles for the overall plot and/or legend are desired. If the user indicates that titles are desired, MODVIEW prompts the user to specify them. The A array is then displayed as 14 numerical ranges.

Interactive Definition of Numerical Ranges. To define the numerical ranges interactively, the user should select option 2 in response to the prompt to choose a method for defining numerical ranges. MODVIEW will then prompt the user to enter the number of numerical ranges to be defined. Next, MODVIEW prompts the user to begin entering the numerical ranges, starting with range one.

Once all the numerical ranges are defined, MODVIEW prompts the user to specify the colors that are to be used to represent the numerical ranges. The colors are specified by entering representative numbers displayed next to the names of the colors.

1 = blue
2 = red
3 = light blue
4 = dark blue
5 = white
6 = army green
7 = yellow
8 = green
9 = orange
10 = brown
11 = purple
12 = gray
13 = pink
14 = dark brown
15 = black

After the colors are specified, MODVIEW prompts the user to indicate whether titles are desired for the overall plot and/or legend. If the user indicates that titles are desired, MODVIEW prompts the user to specify them. MODVIEW then prompts the user to enter the name of a control input file in which the definitions of the numerical ranges, the corresponding colors, and the display titles are to be stored.

External Definition Using Control Input Files. To define the numerical ranges externally using a control input file, the user should select option 3 in response to the prompt to choose a method for defining the numerical ranges. MODVIEW will then prompt the user to specify the name of a pre-existing control input file. Control input files are free-format ASCII files in which statements of the numerical ranges, the corresponding colors, and the plot and/or legend titles are stored. Storing these data precludes respecifying the numerical ranges, the corresponding colors, and the plot and/or legend titles each time the same A array or a similar A array is to be viewed.

Control input files are of two types, absolute and relative. Absolute control input files are most applicable for use in viewing the same array of data more than once. Relative control input files are most applicable for viewing several different arrays of data.

Absolute Control Input Files. In absolute control input files, numerical ranges are stated as absolute numerical values (Figure 3). Information is entered in the following order:

1. HEADER "a"
2. NRANGE
3. XL(1)   XH(1)
   .   .
   .   .
   .   .

   XL(NRANGE)   XH(NRANGE)

```
    File Contents                    Explanations

a                                    Header indicating absolute control file
    5                                Number of numerical ranges
-10.0   -5.0                         Range number 1
 -5.0   -3.0                         Range number 2
 -3.0    0.0                         Range number 3
  0.0    2.0                         Range number 4
  2.0    4.0                         Range number 5
    1                                Color corresponding to range 1 (blue)
    3                                Color corresponding to range 2 (light blue)
    5                                Color corresponding to range 3 (white)
    7                                Color corresponding to range 4 (yellow)
    8                                Color corresponding to range 5 (green)
    3                                Number of plot text strings
Example MODVIEW Plot                 Plot text string 1
(Derived using an absolute           Plot text string 2
 control file)                       Plot text string 3
    2                                Number of legend text strings
Hydraulic-Head Residuals             Legend text string 1
(feet)                               Legend text string 2
```

Figure 3.   Sample absolute control input file

4. NCOLOR(1)

    .
    .
    .

    NCOLOR(NRANGE)
5. NUMTITE1
6. PTITLE(1)

    .
    .
    .

    PTITLE(NUMTITE1)
7. NUMTITE2
8. LTITLE(1)

    .
    .
    .

    LTITLE(NUMTITE2)

"a"	Alphanumeric character denoting that the file is an absolute control input file
NRANGE	Number of numerical ranges to be defined; maximum is 15
XL	Low ends of numerical ranges
XH	High ends of numerical ranges
NCOLOR	Numbers representing colors that correspond to numerical ranges
NUMTITE1	Number of 26-character alphanumeric strings to be specified as the overall plot title; range is zero to five
PTITLE	Alphanumeric strings specified as plot title. Maximum length per string is 26 characters. PTITLE is not specified if NUMTITE1 is specified as zero.

NUMTITE2 Number of 26-character alphanumeric strings to be specified as the legend title; range is zero to three

LTITLE Alphanumeric strings specified as legend title. Maximum length per string is 26 characters. LTITLE is not specified if NUMTITE2 is specified as zero.

Relative Control Input Files. In relative control input files, decimal fractions are specified in place of numerical ranges to account for uncertainty in the maxima and minima of the different A arrays to be viewed (Figure 4). The specification of decimal fractions precludes instances in which members of an A array are either less than the low end of the first numerical range or greater than the high end of the last numerical range of the array.

The sum of the decimal fractions must be 1.0. A set of five such decimal fractions could be stated as follows:

DECIMAL FRACTION 1: 0.10
DECIMAL FRACTION 2: 0.40
DECIMAL FRACTION 3: 0.10
DECIMAL FRACTION 4: 0.20
DECIMAL FRACTION 5: 0.20

Using the decimal fractions, MODVIEW calculates the high and low ends of the corresponding numerical ranges, based on the maximum and minimum values of the A array to be viewed (see appendix).

Information is entered into the relative control input file in the following order:

1. HEADER "r"
2. NRANGE
3. NPER(1)
   .
   .
   .
   NPER(NRANGE)

```
   File Contents                      Explanations

r                                 Header indicating relative control file
   5                              Number of numerical ranges
   0.10                           Decimal fraction corresponding to range 1
   0.20                           Decimal fraction corresponding to range 2
   0.30                           Decimal fraction corresponding to range 3
   0.20                           Decimal fraction corresponding to range 4
   0.20                           Decimal fraction corresponding to range 5
   1                              Color corresponding to range 1 (blue)
   3                              Color corresponding to range 2 (light blue)
   5                              Color corresponding to range 3 (white)
   7                              Color corresponding to range 4 (yellow)
   8                              Color corresponding to range 5 (green)
   3                              Number of plot text strings
Example MODVIEW Plot              Plot text string 1
(Derived using a relative         Plot text string 2
 control file)                    Plot text string 3
   2                              Number of legend text strings
Hydraulic-Head Residuals          Legend text string 1
(feet)                            Legend text string 2
```

Figure 4.   Sample relative control input file

4. NCOLOR(1)

.

.

.

NCOLOR(NRANGE)
5. NUMTITE1
6. PTITLE(1)

.

.

.

PTITLE(NUMTITE1)
7. NUMTITE2
8. LTITLE(1)

.

.

.

LTITLE(NUMTITE2)

"r"	Alphanumeric character denoting that the file is a relative control input file
NRANGE	Number of numerical ranges to be specified; maximum is 15
NPER	Decimal fractions from which numerical ranges are determined
NCOLOR	Numbers representing the colors that correspond to numerical ranges
NUMTITE1	Number of 26-character alphanumeric strings to be specified as the overall plot title; range is zero to five
PTITLE	Alphanumeric strings specified as plot title. Maximum length per string is 26 characters. PTITLE is not specified if NUMTITE1 is specified as zero.
NUMTITE2	Number of 26-character alphanumeric strings to be specified as the legend title; range is zero to three

LTITLE   Alphanumeric strings specified as legend title. Maximum length per string is 26 characters. LTITLE is not specified if NUMTITE2 is specified as zero.

REPRESENTATION OF INACTIVE CELLS

In many MODFLOW datasets, grid cells exist for which data values are not specified or calculated. Such cells are referred to as inactive cells. The positions that correspond to these cells in the A array are filled with a number that otherwise would not be expected. The number "999.0" is used for this purpose in sample problems shown in the MODFLOW user's manual (McDonald and Harbaugh 1988).

In MODVIEW, the user is prompted to specify whether or not inactive cells are to be represented in the dataset to be viewed. If the user indicates that inactive cells are to be represented, MODVIEW prompts the user to specify the number that is being used to represent inactive cells in the A array. This information must be supplied to enable the program to distinguish this number from the other members of the A array. MODVIEW will display grid cells that correspond to the positions of this number in the A array as inactive. MODVIEW displays inactive cells by filling them with white or black, according to user specification. MODVIEW prompts the user to specify either white or black following the prompt by entering the representative number. Inactive cells are defined as such in the legend.

MODVIEW OUTPUT

Screen Output

MODVIEW screen output consists of three types of displays: (1) a primary display, (2) subarea displays, and (3) zoom-reference displays. Compatible graphics cards include EGA, VGA, and super VGA (SVGA).

Primary Display. The primary display consists of the entire MODFLOW finite-difference grid superimposed onto the colored

pattern of numerical ranges, labeled with row and column numbers, and accompanied by a legend in which the numerical ranges are referenced to the colors being used to represent them. Plot and/or legend titles are displayed as well, if specified (Figure 5). The primary display is drawn initially without user specification.

Subarea Displays. Subarea displays consist of a specified subarea of the MODFLOW finite-difference grid superimposed onto a corresponding colored pattern of numerical ranges, labeled with row and column numbers, accompanied by plot and/or legend titles, if specified (Figure 6). Subarea displays are useful for focusing (zooming) on areas of the grid that cannot be seen adequately in the primary display.

To zoom a subarea, the user should press ENTER, type "z", and press ENTER again after the primary display has been drawn. MODVIEW then prompts for the beginning and ending row numbers and column numbers of the subarea to be zoomed. In each case, the user should respond by typing in the two numbers, separated by a blank space or comma. MODVIEW will then draw the subarea display. Other subareas ranging in size from one cell to the entire finite-difference grid (i.e., the primary display) can be displayed thereafter by repeating this procedure.

Zoom-Reference Displays. Zoom-reference displays consist of the overall MODFLOW finite-difference grid with only the zoomed subarea filled in with colors, an accompanying legend, and, if specified, plot and/or legend titles (Figure 7). Zoom-reference displays show the position of a zoomed subarea with respect to the entire model finite-difference grid.

The user instructs MODVIEW to draw a zoom-reference display by pressing ENTER, typing "zr", and pressing ENTER again after the zoomed subarea has been drawn. The user recovers the corresponding subarea display by pressing ENTER, typing "b", and pressing ENTER again after the zoom-reference display has been drawn.

Example MODVIEW Plot
(Derived using an absolute
control file)

Hydraulic-Head Residuals
(feet)

▨	≥-0.100E+02; ≤-0.500E+01
▨	≥-0.500E+01; ≤-0.300E+01
□	≥-0.300E+01; ≤ 0.000E+00
▨	≥ 0.000E+00; ≤ 0.200E+01
▨	≥ 0.200E+01; ≤ 0.400E+01
■	Inactive
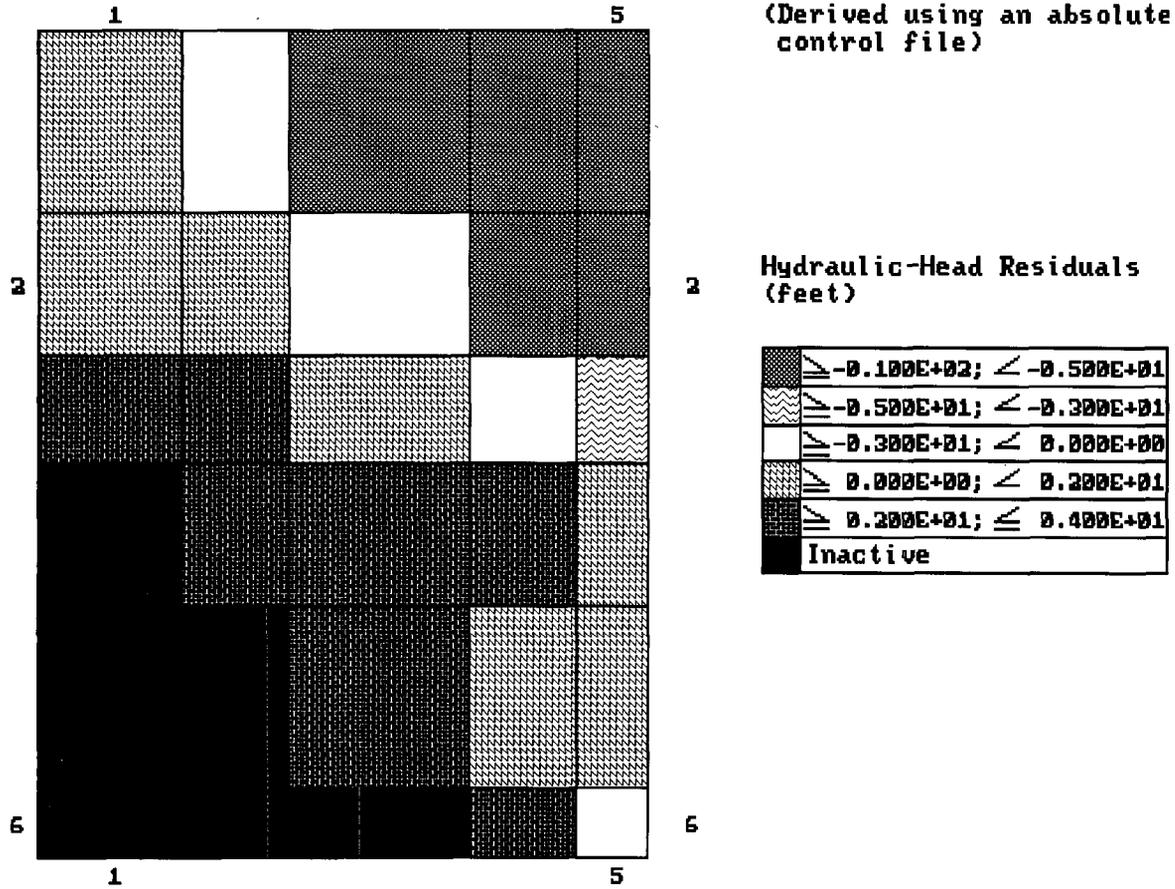
Figure 5.   Primary display corresponding to the sample input file of Figure 2
and the absolute control input file of Figure 3

Example MODVIEW Plot
(Derived using an absolute
control file)

Hydraulic-Head Residuals
(feet)

	$\geq$ -0.100E+02; $\angle$ -0.500E+01
	$\geq$ -0.500E+01; $\angle$ -0.300E+01
	$\geq$ -0.300E+01; $\angle$ 0.000E+00
	$\geq$ 0.000E+00; $\angle$ 0.200E+01
	$\geq$ 0.200E+01; $\leq$ 0.400E+01
	Inactive
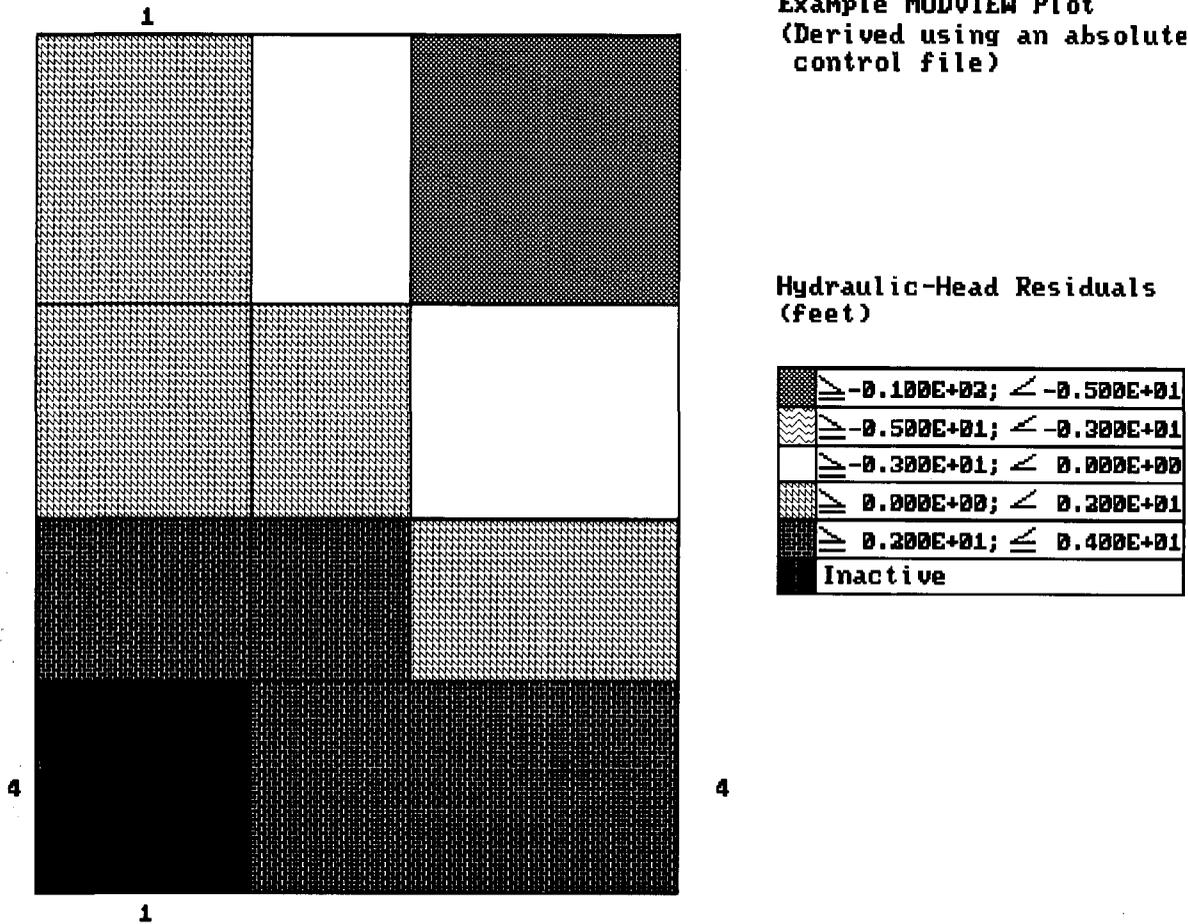
Figure 6.   Subarea display of rows 1–4 and columns 1–3 of the finite-
difference grid of Figure 5
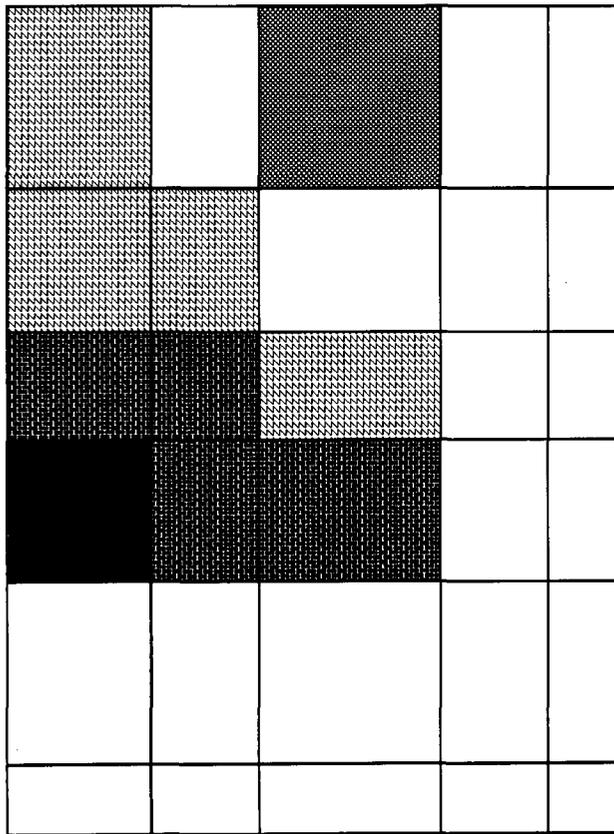
Example MODVIEW Plot
(Derived using an absolute
control file)

Hydraulic-Head Residuals
(feet)

▨	≥-0.100E+02; ≤-0.500E+01
▨	≥-0.500E+01; ≤-0.300E+01
☐	≥-0.300E+01; ≤ 0.000E+00
▨	≥ 0.000E+00; ≤ 0.200E+01
▨	≥ 0.200E+01; ≤ 0.400E+01
■	Inactive

Figure 7. Zoom-reference display corresponding to the subarea display of Figure 6

Hard-Copy Output

MODVIEW has no built-in drivers for hard-copy production. However, hard copies of MODVIEW screen output can be produced using screen-capture programs such as Pizzaz Plus (Application Techniques 1990). Screen-capture programs enable MODVIEW output to be produced in black and white or in color. Output can be printed on dot-matrix, laser, or color printers.

Ensuring Correct Grid Aspect Ratios

MODVIEW version 1.0 is compatible with EGA, VGA, and SVGA graphics cards and color monitors. Most monitors have a switch located on the panel front or back with which to control the height of the screen image. On some monitors, a switch for controlling the width of the screen image is provided also. The ratio of the height of the screen image to the width of the screen image is the screen aspect ratio. The aspect ratios of finite-difference grids drawn by MODVIEW are dependent on the screen aspect ratio. By using the program ASPECT, which is included on the enclosed diskette with MODVIEW, the aspect ratios of grids plotted by MODVIEW can be properly adjusted to a given setting of the screen aspect ratio.

The ASPECT program causes a horizontal line and a vertical line to be drawn at a right angle to one another. To adjust the aspect ratio of MODVIEW grids, the user should measure the lengths of the lines with a ruler. When making the measurements, the ruler should be held parallel to the panel that frames the glass portion of the monitor, not bent to match the curvature of the screen. The measurements should be entered into an ASCII input file called "Aspect" in the following order:

HORIZL VERTL

HORIZL The length of the horizontal line

VERTL   The length of the vertical line

These measurements can be stated in any unit system. The file "Aspect" should be placed in the DOS directory from which MODVIEW is to be executed. During each run, MODVIEW will search for this file only in the current directory. If the file "Aspect" is present, MODVIEW will use the measurements stated in the file to approximate the actual aspect ratio of the finite-difference grid being represented. If the file "Aspect" is not present, then MODVIEW will use default values of the lengths of the horizontal and vertical lines drawn by the ASPECT program. In such cases, the aspect ratio of the grid drawn by MODVIEW will differ from the aspect ratio of the actual model grid to an extent that depends on the setting of the screen aspect ratio.

REPLACING AN EXISTING ARRAY OF DATA

To replace one A array by another A array without first exiting MODVIEW, the user should press ENTER, type "r", and press ENTER again after the primary display, subarea display, or zoom-reference display has been drawn. MODVIEW then prompts the user to enter the name of the new data input file.

RUNNING MODVIEW OR ASPECT

Prior to running MODVIEW or ASPECT, the WATCOM GKS library of graphics functions (Yach 1987) must be loaded into computer memory. To load the graphics library, the user should copy the executable code WGKS.EXE from the accompanying diskette to the desired computer disk drive, type "WGKS", and press ENTER. MODVIEW or ASPECT can then be run by copying the MODVIEW or ASPECT executable code, MODVIEW.EXE or ASPECT.EXE, from the enclosed diskette to the desired disk drive, typing "MODVIEW" or "ASPECT", and pressing ENTER.

EXITING MODVIEW

To exit MODVIEW, the user should press ENTER, type "q", and press ENTER again after the primary display, subarea display, or

zoom-reference display has been drawn. The user is also given the option of exiting while being prompted to specify a method for defining the numerical ranges.

TURNING OFF "MONITOR GRAPHICS MODE"

Running MODVIEW or ASPECT changes the normal operating mode of a monitor. This change will result in a slowing of the scrolling function and sometimes in other abnormal monitor behavior when the monitor is used for other applications. To restore normal operating mode, the user should execute the DOS command "MODE CO80".

PROGRAM PORTABILITY

The MODVIEW source code was compiled using the WATFOR-77 FORTRAN compiler (Coschi and Schueler 1986 and 1987) and WATCOM GKS graphics library (Yach 1987). The resulting MODVIEW executable code will run on IBM-compatible personal computers equipped with EGA, VGA, or SVGA color graphics cards and color monitors. A UNIX version of MODVIEW for use on SUN workstations can be created for use with the SunGKS library of GKS functions (Sun Microsystems 1990).

SUMMARY

MODVIEW is a Graphical-Kernel-System program that enables
datasets arranged in the format of a two-dimensional array to be
viewed as colored patterns of numerical ranges. MODVIEW is
intended primarily to provide a convenient means of viewing
MODFLOW input and output datasets and thus to make
calibrating and evaluating MODFLOW ground water flow models
more efficient.

MODVIEW reads the arrays to be viewed from ASCII input data
files. MODVIEW data input files consist of three general sections:
(1) a statement of the number of rows and columns of the model
finite-difference grid, followed by (2) statements of the widths of
the rows and columns of the model finite-difference grid,
followed by (3) a statement of the array of data to be viewed.

MODVIEW numerical ranges consist of two numbers
representing the high and low ends of an interval of the array of
data to be viewed. Because MODVIEW represents arrays of data
as colored patterns of numerical ranges, the user must define the
numerical ranges prior to viewing. Numerical ranges and
corresponding colors can be defined by three different methods:
(1) automatic definition by MODVIEW, (2) interactive definition
by the user, or (3) external definition through the use of control
input files.

MODVIEW screen output consists of three types of displays: (1) a
primary display, (2) subarea displays, and (3) zoom-reference
displays. The primary display consists of the entire MODFLOW
finite-difference grid superimposed onto the colored pattern of
numerical ranges, labeled with row and column numbers, and
accompanied by a legend in which the numerical ranges are
referenced to the colors used to represent them. Plot and/or
legend titles are displayed as well, if specified. Subarea displays
consist of a specified subarea of the MODFLOW finite-difference
grid superimposed onto a corresponding colored pattern of
numerical ranges, labeled with row and column numbers, and

accompanied by a legend and, if specified, plot and/or legend titles. Zoom-reference displays consist of the overall MODFLOW finite-difference grid with only the zoomed subarea filled in with colors, an accompanying legend, and, if specified, plot and/or legend titles.

MODVIEW will run on IBM-compatible personal computers equipped with EGA, VGA, or SVGA color graphics cards and color monitors. Hard-copy plots of MODVIEW output can be produced with the use of screen-capture programs such as Pizzaz Plus. Screen-capture programs enable MODVIEW output to be produced in black and white or in color. Output can be printed on dot-matrix, laser, or color printers.

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APPENDIX—NOTES ON MODVIEW PROCEDURES FOR DEFINING NUMERICAL RANGES

AUTOMATIC DEFINITION OF NUMERICAL RANGES

Automatic definition of numerical ranges is performed using one of two different approaches, depending on the mean, standard deviation, minimum, and maximum values of the A array.

First Approach

The first approach is used whenever the minimum and maximum values of the array of data are more than one standard deviation from the mean.

To determine whether or nor this is the case, MODVIEW first calculates the mean and standard deviation of the A array. It then determines the upper and lower bounds of the interval of data values within one standard deviation of the mean, as follows:

$$XHSTD = ACAV + STDEV$$

$$XLSTD = ACAV - STDEV$$

where $XHSTD$ and $XLSTD$ are the upper and lower bounds, respectively, of the interval of data values within one standard deviation of the mean, $ACAV$ is the mean of the array of data, and $STDEV$ is the standard deviation of the array of data.

If XHSTD is less than the maximum value and XLSTD is greater than the minimum value of the array of data, then the minimum and maximum values of the A array are more than one standard deviation from the mean and the first approach is used to define the numerical ranges. In this approach, the sizes of the 14 numerical ranges are determined as follows:

Ranges 1 through 4:

$$XINTER = \frac{XLSTD - AMIN}{4.0}$$

Ranges 5 through 10:

$$XINTER = \frac{XHSTD - XLSTD}{6.0}$$

Ranges 11 through 14:

$$XINTER = \frac{AMAX - XHSTD}{4.0}$$

where *XINTER* is the size of the numerical ranges and *AMIN* and *AMAX* are the minimum and maximum values of the A array, respectively.

A larger number of ranges is devoted to the interval of data values within one standard deviation of the mean because, in this approach, a relatively large number of data values are assumed to be clustered about the mean.

The low end of range one is then set equal to AMIN, and the high end is calculated as follows:

$$XHIGH = XLOW + XINTER$$

where *XHIGH* is the high end of range number one and *XLOW* is the low end of range number one. The low end of range number two is then equated to the high end of range number one, and the high end is calculated according to the stated equation. This is repeated for each of the remaining numerical ranges.

If XHSTD is greater than AMAX or XLSTD is less than AMIN, then the second approach is used.

Second Approach

In the second approach, the data values are assumed to be more evenly distributed with respect to the mean; therefore, 14 numerical ranges of equal size are defined, as follows:

Ranges 1 through 14:

$$XINTER = \frac{AMAX - AMIN}{14.0}$$

Once the interval size of the 14 numerical ranges is established, the high and low ends of the numerical ranges are calculated as before.

EXTERNAL DEFINITION USING RELATIVE CONTROL INPUT FILES

MODVIEW converts the decimal fractions as specified in the relative control input file to corresponding numerical ranges. To do this, the decimal fractions are multiplied by the difference in the maximum and minimum values of the array of data to determine the differences in the high and low ends of the corresponding numerical ranges. The low end of range one is then equated to the minimum value of the array of data.

The high end is calculated according to the following equation:

$$XHIGH = XDOM \times XPER + XLOW$$

where *XHIGH* is the high end of the numerical range, *XDOM* is the difference in maximum and minimum values of the array of data, *XPER* is the specified decimal fraction, and *XLOW* is the low end of the numerical range. The low end of range number two is defined by equating it to the high end of range number one. The high end of range number two is determined according to the stated equation. This procedure is repeated until the high and low ends of all the numerical ranges have been calculated.