

Revisions are in red.

Basic Package Input Instructions

The Basic Package reads several files: Name File, Discretization File, Basic Package file, Multiplier Array file, Zone Array file, Output Control Option file, the Time-Variant Specified-Head Option file, and the Parameter Value File. The Name File, Discretization File, and Basic Package file are required for all simulations. The other files are optional.

Name File

The Name File contains the names of most of the input and output files used in a model simulation and controls whether or not parts of the model program are active. (“OPEN/CLOSE” files, described in the Input Instructions for Array Reading Utility Subroutines section, are not included in the Name File.) The Name File is read on unit 99. The Name File is constructed as follows.

FOR EACH SIMULATION

1. Ftype Nunit Fname [Fstatus]

The Name File contains one of the above lines (item 1) for each file. All variables are free format. The length of each line must be 299 characters or less. The lines can be in any order except for the line where Ftype (file type) is “LIST” as described below.

Comment lines are indicated by the # character in column one and can be located anywhere in the file. Any text characters can follow the # character. Comment lines have no effect on the simulation; their purpose is to allow users to provide documentation about a particular simulation. All comment lines after the first item-1 line are written in the listing file.

Explanation of Variables in the Name File:

Ftype—is the file type, which must be one of the following character values. Ftype may be entered in any combination of uppercase and lowercase. (For users of MODFLOW-2000, the GLOBAL file type is no longer supported in MODFLOW-2005.)

LIST for the Listing File—This type must be present and must be the first file in the Name File.

DIS for the Discretization File

BAS6 for the Basic Package

MULT for the multiplier array file

ZONE for the zone array file

OC for the Output Control Option

CHD for the Time-Variant Specified-Head Option

PVAL for the Parameter Value File

BCF6 for the Block-Centered Flow Package

LPF for the Layer Property Flow package

HFB6 for the Horizontal Flow Barrier Package

RCH for the Recharge Package

RIV for the River Package

WEL for the Well Package

DRN for the Drain Package

GHB for the General-Head Boundary Package

EVT for the Evapotranspiration Package

SIP for the Strongly Implicit Procedure Package

PCG for the Preconditioned Conjugate-Gradient Package

DE4 for the Direct Solution Package

DATA(BINARY) for binary (unformatted) files, such as those used to save cell-by-cell budget data and binary (unformatted) head and drawdown data. Files of this type are rewound at the start of each parameter-estimation iteration.

DATA for formatted (text) files, such as those used to save formatted head and drawdown and for input of data from files that are separate from the primary package input files. Files of this type are rewound at the start of each parameter-estimation iteration.

Nunit—is the Fortran unit to be used when reading from or writing to the file. Any legal unit number on the computer being used can be specified except unit 99. Unit 99 is used for the Name File and for reading multi-valued variables using the OPEN/CLOSE option of the utility subroutines (see Input Instructions for Array Reading Utility Subroutines section). The unit number for each file must be unique.

Fname—is the name of the file, which is a character value. Pathnames may be specified as part of Fname.

Fstatus—is the optional file status, which applies only to file types Data and Data(Binary). Two values are allowed: OLD and REPLACE. “Old” indicates that the file should already exist. “Replace” indicates that if the file already exists, then it should be deleted before opening a new file. The default is to open the existing file if the file exists or create a new file if the file does not exist.

Discretization File

Discretization information is read from the file that is specified by "DIS" as the file type.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—“#” must be in column 1. Item 0 can be repeated multiple times.

1. NLAY NROW NCOL NPER ITMUNI LENUNI

2. LAYCBD (NLAY)

3. DELR (NCOL) - U1DREL

Figure 8-1 illustrates the orientation of DELR and DELC.

4. DELC (NROW) - U1DREL

5. Top (NCOL, NROW) - U2DREL

6. BOTM (NCOL, NROW) - U2DREL

Item 6 is repeated for each model layer and Quasi-3D confining bed in the grid. Thus, the number of BOTM variables must be NLAY plus the number of Quasi-3D confining beds. The BOTM variables are read in sequence going down from the top of the system. For example, in a 3-layer model with a Quasi-3D confining bed below layer 2, there would be 4 BOTM arrays. The arrays would be the bottom of layer 1, the bottom of layer 2, the bottom of the Quasi-3D confining bed below layer 2, and the bottom of layer 3.

FOR EACH STRESS PERIOD

7. PERLEN NSTP TSMULT Ss/Tr

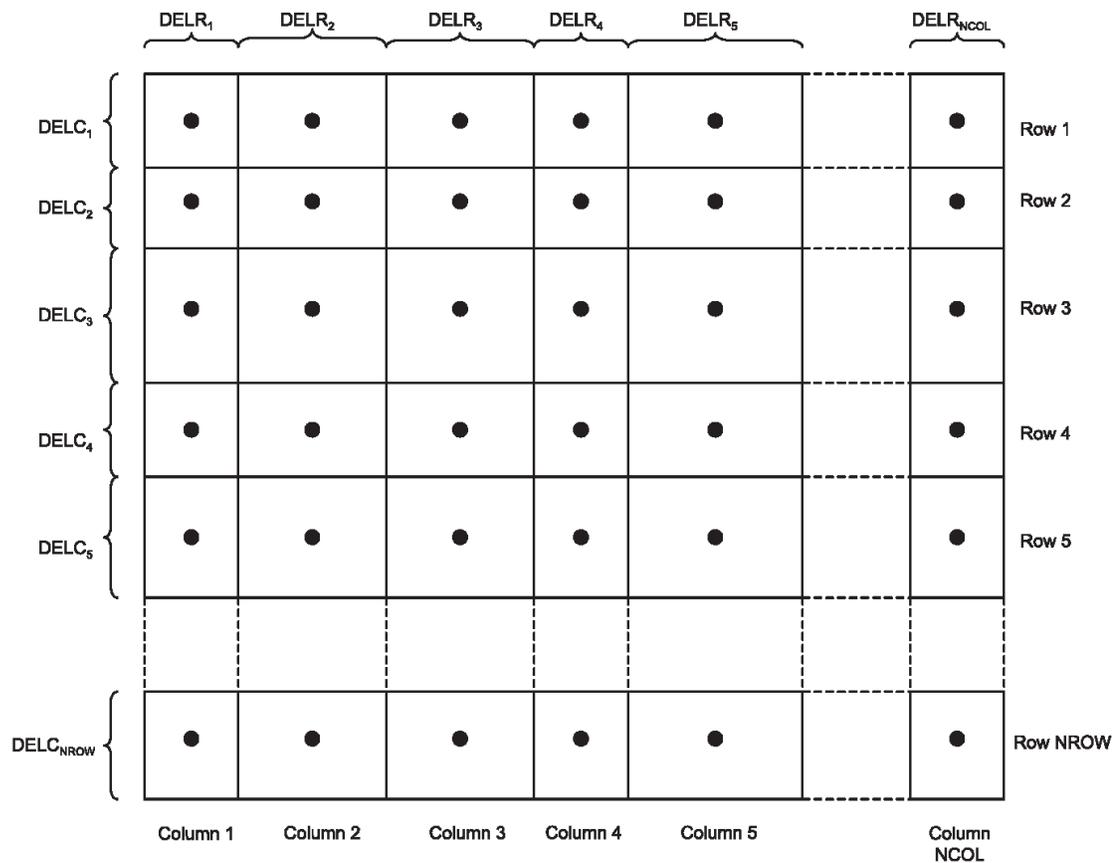


Figure 8-1. Plan view of grid showing DELR and DELC values.

Explanation of Variables Read from the Discretization File:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NLAY—is the number of layers in the model grid.

NROW—is the number of rows in the model grid.

NCOL—is the number of columns in the model grid.

NPER—is the number of stress periods in the simulation.

ITMUNI—indicates the time unit of model data, which must be consistent for all data values that involve time. For example, if years is the chosen time unit, then stress-period length, time-step length, transmissivity, and so on, must all be expressed using years for their time units. Note that the program will still run even if “undefined” time units are specified because the fundamental equations used in MODFLOW do not require that the time unit be identified; but be sure to use consistent units for all input data even when ITMUNI indicates an undefined time unit. When the time unit is defined, MODFLOW uses it to print a table of elapsed simulation time:

- 0 - undefined
- 1 - seconds
- 2 - minutes
- 3 - hours
- 4 - days
- 5 - years

LENUNI—indicates the length unit of model data, which must be consistent for all data values that involve length. For example, if feet is the chosen length unit, grid spacing, head, hydraulic conductivity, water volumes, and so forth, must all be expressed using feet for their length units. Note that the program will still run even if “undefined” length units are specified because the fundamental equations used in MODFLOW do not require that the length unit be identified; but be sure to use consistent units for all input data even when LENUNI indicates an undefined length unit:

- 0 - undefined
- 1 - feet
- 2 - meters
- 3 - centimeters

LAYCBD—is a flag, with one value for each model layer, that indicates whether or not a layer has a Quasi-3D confining bed below it. 0 indicates no confining bed, and not zero indicates a confining bed. LAYCBD for the bottom layer must be 0.

DELR—is the cell width along rows. Read one value for each of the NCOL columns. This is a multi-value one-dimensional variable with one value for each column. (See figure 8-1.)

DELC—is the cell width along columns. Read one value for each of the NROW rows. This is a multi-value one-dimensional variable with one value for each row. (See figure 8-1.)

Top—is the top elevation of layer 1. For the common situation in which the top layer represents a water-table aquifer, setting Top equal to land-surface elevation may be reasonable.

BOTM—is the bottom elevation of a model layer or a Quasi-3d confining bed.

PERLEN—is the length of a stress period.

NSTP—is the number of time steps in a stress period.

TSMULT—is the multiplier for the length of successive time steps. The length of a time step is calculated by multiplying the length of the previous time step by TSMULT. The length of the first time step, Δt_1 , is related to PERLEN, NSTP, and TSMULT by the relation

$$\Delta t_1 = \text{PERLEN} \left(\frac{\text{TSMULT} - 1}{\text{TSMULT}^{\text{NSTP}} - 1} \right).$$

Ss/Tr—is a character variable that indicates whether the stress period is transient or steady state. The only allowed options are “SS” and “TR”, but these are case insensitive.

Basic Package File

The Basic (BAS) Package file is specified with “BAS6” as the file type.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—“#” must be in column 1. Item 0 can be repeated multiple times.

1. Options (199 text characters)

If there are no options to specify, then a blank line must be included for Item 1.

2. IBOUND (NCOL, NROW) or (NCOL, NLAY) -- U2DINT
If not a cross section, a layer variable is read for each layer in the grid.
If a cross section, NLAY rows of NCOL values are read.
3. HNOFLO (10-space field unless Item 1 contains 'FREE'.)
4. STRT (NCOL, NROW) or (NCOL, NLAY) -- U2DREL
If not a cross section, a layer variable is read for each layer in the grid.
If a cross section, NLAY rows of NCOL values are read.

Explanation of Variables Read from the BAS Package File:

Text—is a character variable that starts in column 2. The first two comment lines will become variable HEADNG, which is used as a printout title throughout the program. (If there are no comment lines, then HEADNG will be blank.) HEADNG is limited to 80 columns, but subsequent Text lines can be up to 199 columns. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

Options—is a character variable that is scanned for words (separated by one or more spaces) that specify program options. Three options are currently recognized. Unrecognized words are ignored, and a word may be specified in either uppercase or lowercase. A blank line is acceptable and indicates no options.

XSECTION indicates that the model is a 1-row cross section for which STRT and IBOUND should each be read as single two-dimensional variables with dimensions of NCOL and NLAY. Likewise, head and drawdown should be printed and saved in disk files as single two-dimensional variables.

CHTOCH indicates that flow between adjacent constant-head cells should be calculated.

FREE indicates that free format is used for input variables throughout the Basic Package and other packages as indicated in their input instructions. Be sure that all variables read using free format have a non-blank value and that a comma or at least one blank separates all adjacent values.

STOPERROR STOPER indicates execution of MODFLOW will continue when the solver closure criteria are not met unless the budget error is greater than STOPER. STOPER is the percent error as printed in the budget summary in the MODFLOW listing file. If the budget error is greater than STOPER, then the simulation will stop when the solver closure criteria are not met.

IBOUND—is the boundary variable. One value is read for every model cell. Usually, these values are read one layer at a time; however, when the XSECTION option is specified, a single two-dimensional variable for the cross section is read. Note that although IBOUND is read as one or more two-dimensional variables, IBOUND is stored internally as a three-dimensional variable.

If IBOUND(J,I,K) < 0, cell J,I,K has a constant head.

If IBOUND(J,I,K) = 0, cell J,I,K is no flow.

If IBOUND(J,I,K) > 0, cell J,I,K is variable head.

HNOFLO—is the value of head to be assigned to all no-flow cells (IBOUND = 0). Because head at no-flow cells is unused in model calculations, this does not affect model results but serves to identify no-flow cells when head is printed. This value is used also as drawdown at no-flow cells if the drawdown option is used. Even if the user does not anticipate having no-flow cells, a value for HNOFLO must be entered.

STRT—is initial (starting) head—that is, head at the beginning of the simulation. STRT must be specified for all simulations, including steady-state simulations. One value is read for every model cell. Usually, these values are

MODFLOW-2005 Input Instructions, revised 8-1-2013

read a layer at a time. When the XSECTION option is specified, however, a single two-dimensional variable for the cross section is read. For simulations in which the first stress period is steady state, the values used for STRT generally do not affect the simulation [exceptions may occur if cells go dry and (or) rewet]. The execution time, however, will be less if STRT includes hydraulic heads that are close to the steady-state solution.

Multiplier Array File

Input to define multiplier arrays is read from the file that is specified with "MULT" as the file type. Multiplier arrays can be used to calculate layer variables from parameter values.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. NML

2. MLTNAM [**FUNCTION**]

If Item 2 does not contain the optional **FUNCTION** keyword, read Item 3:

3. [RMLT (NCOL, NROW)] - U2DREL

Otherwise, if Item 2 contains the optional **FUNCTION** keyword, read Item 4:

4. [MLTNAM1 [op1 MLTNAM2] [op2 MLTNAM3] [op3 MLTNAM4] ...]

Repeat items 2 through 4 for each of the NML multiplier arrays.

Explanation of Variables Read from the Multiplier File:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NML—is the number of multiplier arrays to be defined.

MLTNAM—is the name of a multiplier array. This name can consist of 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case are equivalent. The name “NONE” is a reserved word and should not be used for a multiplier array.

FUNCTION—is an optional keyword, which indicates that the multiplier array will be constructed from other multiplier arrays that have already been defined. Construction is by arithmetic combinations of the multipliers; see the explanation below for variable op1, op2, op3

RMLT—is a two-dimensional (one layer) multiplier array.

MLTNAM1, MLTNAM2, MLTNAM3, ...—are the names of multiplier arrays that have already been defined.

op1, op2, op3, ...—are arithmetic operators used to define a multiplier array based on other multiplier arrays. Each operator can be either “+”, “-”, “*”, or “/”. Operations are applied from left to right to each array element. The operators must be separated from the multiplier array names by at least one space.

The following example input illustrates the use of the **FUNCTION** keyword to construct a multiplier array from other multiplier arrays. In this example, three multiplier arrays are defined, and accordingly the first line of the file contains “3”. The first two arrays (named M1 and M2) are read using the U2DREL utility array reader (item 3), and the third array (named M3) is defined as the sum of M1 and M2. In this example, a model layer has 5 rows and 4 columns.

```

3
M1
INTERNAL 1.0 (4F6.0) 0
  1.0 1.1 1.2 1.3
  1.0 1.1 1.2 1.3
  2.0 2.2 2.4 2.6
  2.0 2.2 2.4 2.6
  1.0 1.1 1.2 1.3
M2
INTERNAL 1.0 (4F6.0) 0
  5.0 5.1 5.2 5.3
  5.0 5.1 5.2 5.3
  6.0 6.1 6.2 6.3
  6.0 6.1 6.2 6.3
  5.0 5.1 5.2 5.3
M3 FUNCTION
M1 + M2

```

The resulting values for multiplier M3 are:

```

6.0 6.2 6.4 6.6
6.0 6.2 6.4 6.6
8.0 8.3 8.6 8.9
8.0 8.3 8.6 8.9
6.0 6.2 6.4 6.6

```

Zone Array File

Input to define zone arrays is read from the file that is specified with "ZONE" as the file type. Zone arrays can be used to specify the cells in a layer variable that are associated with a parameter.

FOR EACH SIMULATION

0. [#Text]
Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.
1. NZN
2. ZONNAM
3. IZON(NCOL,NROW) - U2DINT

Items 2-3 are repeated for each of the NZN zone arrays.

Explanation of Variables Read from the Zone File:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NZN—is the number of zone arrays to be defined.

ZONNAM—is the name of a zone array. This name can consist of 1 to 10 characters and is not case sensitive; that is, any combination of the same characters with different case are equivalent. The name “ALL” is a reserved word and should not be used for a zone array.

IZON—is a two-dimensional (one layer) zone array.

Output Control Option

Input to the Output Control Option of the Ground-Water Flow Process is read from the file that is specified as type "OC" in the Name File. If no "OC" file is specified, default output control is used. Under the default, head and overall budget are written to the Listing File at the end of every stress period. The default printout format for head and drawdown is 10G11.4.

Output Control data may be specified as words or numeric codes. One of these methods must be used throughout any simulation.

Output Control Using Words

Recognized words are shown in bold italics; these words must be entered exactly as shown except that they may be entered in either uppercase or lowercase. Optional parts of lines are shown in brackets. One or more spaces must separate each word or variable, and the total line length must not exceed 199 characters.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. Any combination of the following lines:

HEAD PRINT FORMAT IHEDFM

Specifies the format for writing head to the Listing File.

HEAD SAVE FORMAT CHEDFM [**LABEL**]

Specifies the format for writing head to a file other than the Listing File. Omit this line to obtain a binary (unformatted) file. Binary files usually are smaller than text files, but they are not generally transportable among different computer operating systems or different Fortran compilers.

HEAD SAVE UNIT IHEDUN

Specifies the file unit for writing head to a file other than the Listing File.

DRAWDOWN PRINT FORMAT IDDNFM

Specifies the format for writing drawdown to the Listing File.

DRAWDOWN SAVE FORMAT CDDNFM [**LABEL**]

Specifies the format for writing drawdown to a file other than the Listing File. Omit this line to obtain an unformatted (binary) file. Binary files usually are smaller than text files, but they are not generally transportable among different computer operating systems or different Fortran compilers.

DRAWDOWN SAVE UNIT IDDNUN

Specifies the file unit for writing drawdown to a file other than the Listing File.

IBOUND SAVE FORMAT CBOUFM [**LABEL**]

Specifies the format for writing IBOUND to a file.

IBOUND SAVE UNIT IBOUUN

Specifies the file unit for writing IBOUND to a file.

COMPACT BUDGET [**AUX** or **AUXILIARY**]

COMPACT BUDGET indicates that the cell-by-cell budget file(s) will be written in a more compact form than is used in the 1988 version of MODFLOW (referred to as MODFLOW-88)(McDonald and Harbaugh, 1988); however, programs that read these data in the form written by MODFLOW-88 will be unable to read the new compact file. If this option is not used, MODFLOW-2005 will write the files using the MODFLOW-88 form. The optional word **AUX** (or **AUXILIARY**) indicates that auxiliary data that are defined in packages (see input data for the RIV, WEL, DRN, and GHB Packages) should be saved in the budget file along with budget data.

FOR EACH TIME STEP FOR WHICH OUTPUT IS DESIRED

2. **PERIOD** IPEROC **STEP** ITSOC

3. Any combination of the following lines:

PRINT HEAD [list layers if all layers not desired]
Head is written to the Listing File.

PRINT DRAWDOWN [list layers if all layers not desired]
Drawdown is written to the Listing File.

PRINT BUDGET
Overall volumetric budget is written to the Listing File.

SAVE HEAD [list layers if all layers not desired]
Head is written to a file other than the Listing File.

SAVE DRAWDOWN [list layers if all layers not desired]
Drawdown is written to a file other than the Listing File.

SAVE IBOUND [list layers if all layers not desired]
IBOUND is written to a file other than the Listing File. This option is provided to allow changes in IBOUND to be recorded in simulations where IBOUND changes during a simulation.

SAVE BUDGET
Cell-by-cell budget data are written to the files that are designated in the packages that compute budget terms.

Item 2 and one or more Item-3 lines are specified for each time for which output is desired. These lines must be in the order of increasing simulation time.

Explanation of Variables Read by Output Control Using Words:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

IHEDFM—is a code for the format in which heads will be printed. (Positive values indicate wrap format; negative values indicate strip format.)

0 - 10G11.4	11 - 20F5.4
1 - 11G10.3	12 - 10G11.4
2 - 9G13.6	13 - 10F6.0
3 - 15F7.1	14 - 10F6.1
4 - 15F7.2	15 - 10F6.2
5 - 15F7.3	16 - 10F6.3
6 - 15F7.4	17 - 10F6.4
7 - 20F5.0	18 - 10F6.5
8 - 20F5.1	19 - 5G12.5
9 - 20F5.2	20 - 6G11.4
10 - 20F5.3	21 - 7G9.2

CHEDFM—is a character value that specifies the format for saving heads, and can only be specified if the word method of output control is used. The format must contain 20 characters or less and must be a valid Fortran format that is enclosed in parentheses. The format must be enclosed in apostrophes if it contains one or more blanks or commas. The optional word **LABEL** after the format is used to indicate that each layer of output should be preceded with a line that defines the output (simulation time, the layer being output, and so forth). If there is no line specifying CHEDFM, then heads are written to a binary (unformatted) file. Binary files are usually more compact than text files, but they are not generally transportable among different computer operating systems or different Fortran compilers.

IHEDUN—is the unit number on which heads will be saved.

IDDNFM—is a code for the format in which drawdowns will be printed. The codes are the same as for IHEDFM.

CDDNFM—is a character value that specifies the format for saving drawdown, and can only be specified if the word method of output control is used. The format must contain 20 characters or less and must be a valid Fortran format that is enclosed in parentheses. The format must be enclosed in apostrophes if it contains one or more blanks or commas. The optional word **LABEL** after the format is used to indicate that each layer of output should be preceded with a line that defines the output (simulation time, the layer being output, and so forth). If there is no line specifying CDDNFM, then drawdown is written to a binary (unformatted) file. Binary files are usually more compact than text files, but they are not generally transportable among different computer operating systems or different Fortran compilers.

IDDNUN—is the unit number on which drawdowns will be saved.

CBOUFM—is a character value that specifies the format for saving IBOUND, and can only be specified if the word method of output control is used. The format must contain 20 characters or less and must be a valid Fortran format that is enclosed in parentheses. The format must be enclosed in apostrophes if it contains one or more blanks or commas. The optional word **LABEL** is used to indicate that each layer of output should be preceded with a line that defines the output (simulation time, the layer being output, and so forth). If there is no line specifying CBOUFM, then IBOUND is written using format (2014). IBOUND is never written as a binary (unformatted) file.

IBOUUN—is the unit number on which IBOUND will be saved.

IPEROC—is the stress period number at which output is desired.

ITSOC—is the time step number (within a stress period) at which output is desired.

Example Output Control Input Using Words:

```
HEAD PRINT FORMAT 15
HEAD SAVE FORMAT (20F10.3) LABEL
HEAD SAVE UNIT 30
COMPACT BUDGET
DRAWDOWN PRINT FORMAT 14
```

```
PERIOD 1 STEP 1
  PRINT HEAD 2 6
  PRINT DRAWDOWN
  PRINT BUDGET
  SAVE BUDGET
  SAVE HEAD
```

```
PERIOD 1 STEP 7
  SAVE HEAD 1 3 5
  PRINT DRAWDOWN
  SAVE BUDGET
```

```
PERIOD 2 STEP 5
  PRINT HEAD
  PRINT BUDGET
  SAVE BUDGET
  SAVE HEAD
```

Note that the first line cannot be blank, but after the first line blank lines are ignored when the word method is used to specify Output Control data. Indented lines are allowed because of the use of free format input.

Output Control Using Numeric Codes

All variables are free format if the word FREE is specified in Item 1 of the Basic Package input file; otherwise, the variables all have 10-character fields.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—“#” must be in column 1. Item 0 can be repeated multiple times.

1. IHEDFM IDDNFM IHEDUN IDDNUN

FOR EACH TIME STEP

2. INCODE IHDDFL IBUDFL ICBCFL

3. Hdpr Ddpr Hdsv Ddsv

(Item 3 is read 0, 1, or NLAY times, depending on the value of INCODE.)

Explanation of Variables Read by Output Control Using Numeric Codes:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

IHEDFM—is a code for the format in which heads will be printed. See the description above in the explanation of variables read by output control using words.

IDDNFM—is a code for the format in which drawdowns will be printed. The codes are the same as for IHEDFM.

IHEDUN—is the unit number on which heads will be saved.

IDDNUN—is the unit number on which drawdowns will be saved.

INCODE—is the code for reading Item 3.

If INCODE < 0, Item 3 flags are used from the last time step. Item 3 is not read.

If INCODE = 0, all layers are treated the same way. Item 3 will consist of one line.

If INCODE > 0, Item 3 will consist of one line for each layer.

IHDDFL—is a head and drawdown output flag. This flag allows Item 3 flags to be specified in an early time step and then used or not used in subsequent time steps. Thus, using IHDDFL to avoid resetting Item 3 flags every time step may be possible.

If IHDDFL = 0, no heads or drawdowns will be printed or saved regardless of which Item 3 flags are specified.

If IHDDFL ≠ 0, heads and drawdowns will be printed or saved according to the Item 3 flags.

IBUDFL—is a budget print flag.

If IBUDFL = 0, overall volumetric budget will not be printed.

If IBUDFL ≠ 0, overall volumetric budget will be printed.

ICBCFL—is a flag for writing cell-by-cell flow data.

If ICBCFL = 0, cell-by-cell flow terms are not written to any file.

If ICBCFL ≠ 0, cell-by-cell flow terms are written to the LIST file or a budget file depending on flags set in the component of flow packages, that is, IWELCB, IRCHCB, and so forth.

Hdpr—is the output flag for head printout.

If Hdpr = 0, head is not printed for the corresponding layer.

If Hdpr ≠ 0, head is printed for the corresponding layer.

Ddpr—is the output flag for drawdown printout.

If Ddpr = 0, drawdown is not printed for the corresponding layer.

If Ddpr ≠ 0, drawdown is printed for the corresponding layer.

Hdsv—is the output flag for head save.

If Hdsv = 0, head is not saved for the corresponding layer.

If Hdsv ≠ 0, head is saved for the corresponding layer.

Ddsv—is the output flag for drawdown save.

If Ddsv = 0, drawdown is not saved for the corresponding layer.

If Ddsv ≠ 0, drawdown is saved for the corresponding layer.

Time-Variant Specified-Head Option

Input to the Time-Variant Specified-Head (CHD) Option is read from the file that has file type "CHD" in the Name File. Optional variables are shown in brackets. All variables are free format if the option “FREE” is specified

in the Basic Package input file; otherwise, the non-optional variables have 10-character fields and the optional variables are free format.

Once a cell is made constant head, the cell stays constant head throughout the remainder of the simulation. For example, if a cell is listed in the CHD file as constant head in stress period 1 and not listed in stress period 2, then the cell continues to be constant head in stress period 2 and throughout the remainder of the stress periods. The head is adjusted only in the stress periods in which a cell is listed. For the stress periods in which a constant-head cell is not listed, the head stays at the value that it had at the end of the previous stress period.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—“#” must be in column 1. Item 0 can be repeated multiple times.

1. [**PARAMETER** NPCHD MXL]

This optional item must start with the word “PARAMETER”.

2. MXACTC [Option]

3. [PARNAM PARTYP Parval NLST]

4. [Layer Row Column Shdfact Ehdfact [xyz]]

Repeat Items 3 and 4 NPCHD times. Items 3 and 4 are not read if NPCHD is negative or 0.

NLST repetitions of Item 4 are required; they are read by subroutine ULSTRD. (SFAC of the ULSTRD utility subroutine applies to Shdfact and Ehdfact).

FOR EACH STRESS PERIOD

5. ITMP NP

6. Layer Row Column Shead Ehead [xyz]

ITMP repetitions of Item 6 are read by subroutine ULSTRD if ITMP > 0. (SFAC of the ULSTRD utility subroutine applies to Shead and Ehead.) Item 6 is not read if ITMP is negative or 0.

7. [Pname]

(Item 7 is repeated NP times. Item 7 is not read if NP is negative or 0.)

Explanation of Variables Read by the CHD Option:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NPCHD—is the number of constant-head boundary parameters.

MXL—is the maximum number of constant-head-boundary cells that will be defined using parameters.

MXACTC—is the maximum number of constant-head boundary cells in use during any stress period, including those that are defined using parameters.

Option—is an optional list of character values.

“AUXILIARY abc” or “AUX abc”—defines an auxiliary variable, named "abc", which will be read for each constant-head boundary as part of Items 4 and 6. Up to 20 variables can be specified, each of which must be

MODFLOW-2005 Input Instructions, revised 8-1-2013

preceded by "AUXILIARY" or "AUX." These variables will not be used by the Ground-Water Flow Process, but they will be available for use by other processes. The auxiliary variable values will be read after the Ehead variable.

PARNAM—is the name of a parameter. This name can consist of 1 to 10 characters and is not case sensitive; that is, any combination of the same characters with different case will be equivalent.

PARTYP—is the type of parameter to be defined. For the CHD Package, the only allowed parameter type is CHD, which defines values of the start and end head at the boundary.

Parval—is the parameter value. This parameter value may be overridden by a value in the Parameter Value File.

NLST—is the number of constant-head cells that are included in the parameter.

Layer—is the layer number of the constant-head boundary.

Row—is the row number of the constant-head boundary.

Column—is the column number of the constant-head boundary.

Shdfact—is the factor used to calculate the head at the boundary at the start of the stress period from the parameter value. The head is the product of Shdfact and the parameter value.

Ehdfact—is the factor used to calculate the head at the boundary at the end of the stress period from the parameter value. The head is the product of Ehdfact and the parameter value.

ITMP—is a flag and a counter.

If $ITMP < 0$, non-parameter CHD data from the preceding stress period will be reused.

If $ITMP \geq 0$, ITMP is the number of non-parameter constant-head boundaries read for the current stress period.

NP—is the number of parameters in use in the current stress period.

Shead—is the head at the boundary at the start of the stress period.

Ehead—is the head at the boundary at the end of the stress period.

[xyz]—represents the values of the auxiliary variables for a constant-head boundary that have been defined in Item 2. The values of auxiliary variables must be present in each repetition of Items 4 and 6 if they are defined in Item 2. The values must be specified in the order used to define the variables in Item 2.

Pname—is the name of a parameter that is being used in the current stress period. NP parameter names will be read.

Parameter Value File

The Parameter Value File is the file that is specified with "PVAL" as the file type. Parameter values in this file replace parameter values specified in the files where parameters are defined.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. NP

2. PARNAM Parval

NP repetitions of Item 2 are read.

Explanation of Variables Read from the Parameter Value File:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

PARNAM—is the name of a parameter whose value is to be defined. This name can consist of 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent.

Parval—is the parameter value. This value overrides the parameter value specified in the file where the parameter is defined.

Block-Centered Flow Package

Input for the Block-Centered Flow (BCF) Package is read from the file that is type "BCF6" in the Name File. The BCF Package is an alternative to the LPF Package. Both packages should not be used simultaneously.

FOR EACH SIMULATION

1. IBCFCB HDRY IWDFLG WETFCT IWETIT IHDWET

These six variables are free format if the option "FREE" is specified in the Basic Package input file; otherwise, the variables all have 10-character fields.

2. Ltype (NLAY)

Read one value for each layer. These values are free format if the word FREE is specified in Item 1 of the Basic Package input file; otherwise, the values are read using fixed format fields that are each 2 characters wide with 40 values per line. Use only as many lines as required for the number of model layers.

3. TRPY (NLAY) -- U1DREL

A subset of the following two-dimensional variables is used to describe each layer. The variables needed for each layer depend on the layer-type code (LAYCON, which is defined as part of the Item-2 Ltype), whether the simulation has any transient stress periods (at least one stress period defined in the Discretization File specifies Ss/Tr as "TR"), and if the wetting capability is active (IWDFLG not 0). Unneeded variables must be omitted. In no situation will all variables be required. The required variables (Items 4-9) for layer 1 are read first; then the variables for layer 2 and so forth.

4. [Sf1 (NCOL, NROW)] -- U2DREL If there is at least one transient stress period.

If LAYCON is 0 or 2 (see Ltype), then read item 5.

5. [Tran (NCOL, NROW)] -- U2DREL.

Otherwise, if LAYCON is 1 or 3 (see Ltype), read item 6.

6. [HY (NCOL, NROW)] -- U2DREL

7. [Vcont (NCOL, NROW)] -- U2DREL If not the bottom layer.

8. [Sf2 (NCOL, NROW)] -- U2DREL If there is at least one transient stress period and LAYCON (see Ltype) is 2 or 3.

9. [WETDRY (NCOL, NROW)] -- U2DREL If IWDFLG is not 0 and LAYCON is 1 or 3 (see Ltype).

Explanation of Variables Read by the BCF Package:

IBCFCB—is a flag and a unit number.

If IBCFCB > 0, cell-by-cell flow terms will be written to this unit number when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control. The terms that are saved are storage, constant-head flow, and flow between adjacent cells.

If IBCFCB = 0, cell-by-cell flow terms will not be written.

If IBCFCB < 0, cell-by-cell flow for constant-head cells will be written in the listing file when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control. Cell-by-cell flow to storage and between adjacent cells will not be written to any file.

HDRY—is the head that is assigned to cells that are converted to dry during a simulation. Although this value plays no role in the model calculations, HDRY values are useful as indicators when looking at the resulting heads that are output from the model. HDRY is thus similar to HNOFLO in the Basic Package, which is the value assigned to cells that are no-flow cells at the start of a model simulation.

IWDFLG—is a flag that determines if the wetting capability is active.

If IWDFLG = 0, the wetting capability is inactive.

If IWDFLG is not 0, the wetting capability is active.

WETFCT—is a factor that is included in the calculation of the head that is initially established at a cell when that cell is converted from dry to wet. (See IHDWET.)

IWETIT—is the iteration interval for attempting to wet cells. Wetting is attempted every IWETIT iteration. This applies to outer iterations and not inner iterations. If IWETIT is 0, the value is changed to 1.

IHDWET—is a flag that determines which equation is used to define the initial head at cells that become wet:

If IHDWET = 0, equation 5-32A is used:

$$h = \text{BOT} + \text{WETFCT} (h_n - \text{BOT})$$

If IHDWET is not 0, equation 5-32B is used:

$$h = \text{BOT} + \text{WETFCT} (\text{THRESH})$$

Ltype—contains a combined code for each layer that specifies both the layer type (LAYCON) and the method of computing interblock conductance. Use as many lines as needed to enter a value for each layer. Values are two-digit numbers:

The left digit defines the method of calculating interblock transmissivity. The methods are described by Goode and Appel (1992).

0 or blank—harmonic mean (the method used in MODFLOW-88).

1—arithmetic mean

2—logarithmic mean

3—arithmetic mean of saturated thickness and logarithmic-mean hydraulic conductivity.

The right digit defines the layer type (LAYCON), which is the same as in MODFLOW-88:

0—confined—Transmissivity and storage coefficient of the layer are constant for the entire simulation.

1—unconfined—Transmissivity of the layer varies and is calculated from the saturated thickness and hydraulic conductivity. The storage coefficient is constant. This type code is valid only for layer 1.

2—confined/unconfined—Transmissivity of the layer is constant. The storage coefficient may alternate between confined and unconfined values. Vertical flow from above is limited if the layer desaturates.

3—confined/unconfined—Transmissivity of the layer varies and is calculated from the saturated thickness and hydraulic conductivity. The storage coefficient may alternate between confined and unconfined values.

Vertical flow from above is limited if the aquifer desaturates.

TRPY—is a one-dimensional variable containing a horizontal anisotropic factor for each layer and is the ratio of transmissivity or hydraulic conductivity (whichever is being used) along a column to transmissivity or hydraulic conductivity along a row. Set to 1.0 for isotropic conditions. This is a single variable with one value per layer. Do not read a variable for each layer—that is, include only one array control line for the entire variable.

Sf1—is the primary storage coefficient. Read only if one or more transient stress periods are specified in the Discretization File. For LAYCON equal to 1, Sf1 will always be specific yield, whereas for LAYCON equal to 2 or 3, Sf1 will always be confined storage coefficient. For LAYCON equal to 0, Sf1 would normally be confined storage coefficient; however, a LAYCON value of 0 also can be used to simulate water-table conditions where drawdowns everywhere are expected to remain a small fraction of the saturated thickness, and where there is no layer above, or flow from above is negligible. In this case, specific yield values would be entered for Sf1.

Tran—is the transmissivity along rows. Tran is multiplied by TRPY to obtain transmissivity along columns. Read only for layers where LAYCON is 0 or 2.

HY—is the hydraulic conductivity along rows. HY is multiplied by TRPY to obtain hydraulic conductivity along columns. Read only for layers where LAYCON is 1 or 3.

Vcont—is the vertical hydraulic conductivity divided by the thickness from a layer to the layer below (also called leakance). The value for a cell is the hydraulic conductivity divided by thickness for the material between the node in that cell and the node in the cell below. Because there is not a layer beneath the bottom layer, Vcont cannot be specified for the bottom layer.

Sf2—is the secondary storage coefficient. Read only for layers where LAYCON is 2 or 3 and only if there are one or more transient stress periods specified in the Discretization File. The secondary storage coefficient is always specific yield.

WETDRY—is a combination of the wetting threshold (THRESH) and a flag to indicate which neighboring cells can cause a cell to become wet. If $WETDRY < 0$, only the cell below a dry cell can cause the cell to become wet. If $WETDRY > 0$, the cell below a dry cell and the four horizontally adjacent cells can cause a cell to become wet. If WETDRY is 0, the cell cannot be wetted. The absolute value of WETDRY is the wetting threshold. When the sum of BOT and the absolute value of WETDRY at a dry cell is equaled or exceeded by the head at an adjacent cell, the cell is wetted. Read only if LAYCON is 1 or 3 and IWDFLG is not 0.

Layer-Property Flow Package

Input for the Layer-Property Flow (LPF) Package is read from the file that is type "LPF" in the Name File. Free format is used for reading all values. The LPF Package is an alternative to the BCF Package. The two packages should not be used simultaneously.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. ILPFCB HDRY NPLPF [Options]

2. LAYTYP (NLAY)

3. LAYAVG (NLAY)

4. CHANI (NLAY)

5. LAYVKA (NLAY)

6. LAYWET (NLAY)

7. [WETFCT IWETIT IHDWET]

(Include item 7 only if LAYWET indicates at least one wettable layer.)

8. [PARNAM PARTYP Parval NCLU]

9. [Layer Mltarr Zonarr IZ]

Each repetition of Item 9 is called a parameter cluster. Repeat Item 9 NCLU times.

Repeat Items 8-9 for each parameter to be defined (that is, NPLPF times).

A subset of the following two-dimensional variables is used to describe each layer. All the variables that apply to layer 1 are read first, followed by layer 2, followed by layer 3, and so forth. A variable not required due to simulation options (for example, Ss and Sy for a completely steady-state simulation) must be omitted from the input file.

These variables are either read by the array-reading utility subroutine, U2DREL, or they are defined through parameters. If a variable is defined through parameters, then the variable itself is not read; however, a single line containing a print code is read in place of the control line. The print code determines the format for printing the values of the variable as defined by parameters. The print codes are the same as those used in a control line. If any parameters of a given type are used, parameters must be used to define the corresponding variable for all layers in the model.

10. HK (NCOL, NROW)

If any HK parameters are included, read only a print code.

11. [HANI (NCOL, NROW)]

Include item 11 only if CHANI is less than or equal to 0. If any HANI parameters are included, read only a print code.

12. VKA (NCOL, NROW)

If any VK or VANI parameters are included, read only a print code.

13. [Ss (NCOL, NROW)]

Include item 13 only if at least one stress period is transient. If there are any SS parameters, read only a print code.

MODFLOW-2005 Input Instructions, revised 8-1-2013

14. [SY (NCOL, NROW)] Include item 14 only if at least one stress period is transient and LAYTYP is not 0. If any SY parameters are included, read only a print code.
15. [VKCB (NCOL, NROW)] Include item 15 only if LAYCBD (in the Discretization File) is not 0. If any VKCB parameters are included, read only a print code.
16. [WETDRY (NCOL, NROW)] Include item 16 only if LAYWET is not 0 and LAYTYP is not 0.

Explanation of Variables Read by the LPF Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

ILPFCB—is a flag and a unit number.

If ILPFCB > 0, cell-by-cell flow terms will be written to this unit number when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control. The terms that are saved are storage, constant-head flow, and flow between adjacent cells.

If ILPFCB = 0, cell-by-cell flow terms will not be written.

If ILPFCB < 0, cell-by-cell flow for constant-head cells will be written in the listing file when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control. Cell-by-cell flow to storage and between adjacent cells will not be written to any file.

HDRY—is the head that is assigned to cells that are converted to dry during a simulation. Although this value plays no role in the model calculations, HDRY values are useful as indicators when looking at the resulting heads that are output from the model. HDRY is thus similar to HNOFLO in the Basic Package, which is the value assigned to cells that are no-flow cells at the start of a model simulation.

NPLPF—is the number of LPF parameters.

Options—are optional key words that activate options:

STORAGECOEFFICIENT indicates that variable Ss and SS parameters are read as storage coefficient rather than specific storage.

CONSTANTCV indicates that vertical conductance for an unconfined cell is computed from the cell thickness rather than the saturated thickness.

THICKSTRT indicates that layers having a negative LAYTYP are confined, and their cell thickness for conductance calculations will be computed as STRT-BOT rather than TOP-BOT.

NOCVCORRECTION indicates that vertical conductance is not corrected when the vertical flow correction is applied.

NOVFC indicates that the vertical flow correction under dewatered conditions (described on p. 5-8 of USGS Techniques and Methods Report 6-A16) is turned off. Also, the vertical conduction correction described on p. 5-18 of that report is turned off.

NOPARCHECK indicates that, when parameters define an array, there is no check to see if a value is defined for all cells. The value is 0 at cells for which parameters do not define a value. If this option is not specified, the simulation aborts if a value is not defined for all cells.

LAYTYP—contains a flag for each layer that specifies the layer type.

0 – confined

>0 – convertible

<0 – convertible unless the THICKSTRT option is in effect. When THICKSTRT is in effect, a negative value of LAYTYP indicates that the layer is confined, and its saturated thickness will be computed as STRT-BOT.

LAYAVG—contains a flag for each layer that defines the method of calculating interblock transmissivity.

0—harmonic mean

1—logarithmic mean

2—arithmetic mean of saturated thickness and logarithmic-mean hydraulic conductivity.

CHANI—contains a value for each layer that is a flag or the horizontal anisotropy. If CHANI is less than or equal to 0, then variable HANI defines horizontal anisotropy. If CHANI is greater than 0, then CHANI is the horizontal anisotropy for the entire layer, and HANI is not read. If any HANI parameters are used, CHANI for all layers must be less than or equal to 0.

LAYVKA—contains a flag for each layer that indicates whether variable VKA is vertical hydraulic conductivity or the ratio of horizontal to vertical hydraulic conductivity.

0—indicates VKA is vertical hydraulic conductivity

not 0—indicates VKA is the ratio of horizontal to vertical hydraulic conductivity, where the horizontal hydraulic conductivity is specified as HK in item 10.

LAYWET—contains a flag for each layer that indicates whether wetting is active.

0—indicates wetting is inactive

not 0—indicates wetting is active

WETFCT—is a factor that is included in the calculation of the head that is initially established at a cell when the cell is converted from dry to wet. (See IHDWET.)

IWETIT—is the iteration interval for attempting to wet cells. Wetting is attempted every IWETIT iteration. If using the PCG solver (Hill, 1990), this applies to outer iterations, not inner iterations. If $IWETIT \leq 0$, the value is changed to 1.

IHDWET—is a flag that determines which equation is used to define the initial head at cells that become wet:

If IHDWET = 0, equation 5-32A is used: $h = BOT + WETFCT (h_n - BOT)$.

If IHDWET is not 0, equation 5-32B is used: $h = BOT + WETFCT(THRESH)$.

PARNAM—is the name of a parameter to be defined. This name can consist of 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent.

PARTYP—is the type of parameter to be defined. For the LPF Package, the allowed parameter types are:

HK—defines variable HK, horizontal hydraulic conductivity

HANI—defines variable HANI, horizontal anisotropy

VK—defines variable VKA for layers for which VKA represents vertical hydraulic conductivity (LAYVKA=0)

VANI—defines variable VKA for layers for which VKA represents vertical anisotropy (LAYVKA≠0)

SS—defines variable Ss, the specific storage

SY—defines variable Sy, the specific yield

VKCB—defines variable VKCB, the vertical hydraulic conductivity of a Quasi-3D confining layer.

Parval—is the parameter value. This parameter value may be overridden by a value in the Parameter Value File.

NCLU—is the number of clusters required to define the parameter. Each repetition of Item 9 is a cluster (variables Layer, Mltarr, Zonarr, and IZ). Each layer that is associated with a parameter usually has only one cluster. For example, parameters which apply to cells in a single layer generally will be defined by just one cluster. However, having more than one cluster for the same layer is acceptable.

Layer—is the layer number to which a cluster definition applies.

MODFLOW-2005 Input Instructions, revised 8-1-2013

Mltarr—is the name of the multiplier array to be used to define variable values that are associated with a parameter. The name “NONE” means that there is no multiplier array, and the variable values will be set equal to Parval.

Zonarr—is the name of the zone array to be used to define the cells that are associated with a parameter. The name “ALL” means that there is no zone array, and all cells in the specified layer are part of the parameter.

IZ—is up to 10 zone numbers (separated by spaces) that define the cells that are associated with a parameter. These values are not used if ZONARR is specified as “ALL”. Values can be positive or negative, but 0 is not allowed. The end of the line, a zero value, or a non-numeric entry terminates the list of values.

HK—is the hydraulic conductivity along rows. HK is multiplied by horizontal anisotropy (see CHANI and HANI) to obtain hydraulic conductivity along columns.

HANI—is the ratio of hydraulic conductivity along columns to hydraulic conductivity along rows, where HK of item 10 specifies the hydraulic conductivity along rows. Thus, the hydraulic conductivity along columns is the product of the values in HK and HANI. Read only if CHANI \leq 0.

VKA—is either vertical hydraulic conductivity or the ratio of horizontal to vertical hydraulic conductivity depending on the value of LAYVKA. If LAYVKA is 0, VKA is vertical hydraulic conductivity. If LAYVKA is not 0, VKA is the ratio of horizontal to vertical hydraulic conductivity. In this case, HK is divided by VKA to obtain vertical hydraulic conductivity, and values of VKA typically are greater than or equal to 1.0.

Ss—is specific storage unless the STORAGECOEFFICIENT option is used. When STORAGECOEFFICIENT is used, Ss is confined storage coefficient. Read only for a transient simulation (at least one transient stress period).

Sy—is specific yield. Read only for a transient simulation (at least one transient stress period) and if the layer is convertible (LAYTYP is not 0).

VKCB—is the vertical hydraulic conductivity of a quasi-three-dimensional confining bed below a layer. Read only if there is a confining bed. Because the bottom layer cannot have a confining bed, VKCB cannot be specified for the bottom layer.

WETDRY—is a combination of the wetting threshold and a flag to indicate which neighboring cells can cause a cell to become wet. If WETDRY $<$ 0, only the cell below a dry cell can cause the cell to become wet. If WETDRY $>$ 0, the cell below a dry cell and the four horizontally adjacent cells can cause a cell to become wet. If WETDRY is 0, the cell cannot be wetted. The absolute value of WETDRY is the wetting threshold. When the sum of BOT and the absolute value of WETDRY at a dry cell is equaled or exceeded by the head at an adjacent cell, the cell is wetted. Read only if LAYTYP is not 0 and LAYWET is not 0.

Horizontal Flow Barrier Package

Input for the Horizontal Flow Barrier (HFB) Package is read from the file that has file type “HFB6” in the Name File. All variables are read in free format.

FOR EACH SIMULATION

0. [#Text]
Item 0 is optional—“#” must be in column 1. Item 0 can be repeated multiple times.
1. NPHFB MXFB NHFBNP
2. [PARNAM PARTYP Parval NLST]
3. [Layer IROW1 ICOL1 IROW2 ICOL2 Factor]
Repeat Items 2 and 3 NPHFB times. Items 2 and 3 are not read if NPHFB is negative or zero.
NLST repetitions of Item 3 are required; they are read by subroutine ULSTRD. (SFAC of the ULSTRD utility subroutine applies to Factor).
4. Layer IROW1 ICOL1 IROW2 ICOL2 Hydchr
NHFBNP repetitions of Item 4 are read. Item 4 is not read if NHFBNP is negative or zero.
5. NACTHFB
6. Pname
NACTHFB repetitions of Item 6 are read. Item 6 is not read if NACTHFB is negative or zero.

Explanation of Variables Read by the HFB Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NPHFB—is the number of horizontal flow barrier parameters to be defined in Items 2 and 3. Note: An HFB parameter must be defined in Items 2 and 3, and made active using Item 6, to have an effect in the simulation.

MXFB—is the maximum number of HFB barriers that will be defined using parameters.

NHFBNP—is the number of HFB barriers not defined by parameters.

PARNAM—is the name of a parameter. This name can consist of 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent.

PARTYP—is the type of parameter. For the HFB Package, the only allowed parameter type is HFB, which defines values of the hydraulic characteristic of the barrier.

Parval—is the parameter value. This parameter value may be overridden by a value in the Parameter Value File.

NLST—is the number of horizontal flow barrier cells included in the parameter.

Layer—is the number of the model layer in which the horizontal flow barrier is located.

IROW1—is the row number of the cell on one side of the horizontal flow barrier.

ICOL1—is the column number of the cell on one side of the horizontal flow barrier.

IROW2—is the row number of the cell on the other side of the horizontal flow barrier.

ICOL2—is the column number of the cell on the other side of the horizontal flow barrier.

Factor—is the factor used to calculate hydraulic characteristic from the parameter value. The hydraulic characteristic is the product of Factor and the parameter value.

Hydchr—is the hydraulic characteristic of the horizontal flow barrier. The hydraulic characteristic is the barrier hydraulic conductivity divided by the width of the horizontal flow barrier.

NACTHFB—is the number of active HFB parameters.

Pname—is the name of a parameter to be used in the simulation. NACTHFB parameter names will be read.

River Package

Input to the River (RIV) Package is read from the file that has file type "RIV" in the Name File. Optional variables are shown in brackets. All variables are free format if the option "FREE" is specified in the Basic Package input file; otherwise, the non-optional variables have 10-character fields and the optional variables are free format.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. [**PARAMETER** NPRIV MXL]

This optional item must start with the word "PARAMETER".

2. MXACTR IRIVCB [Option]

3. [PARNAM PARTYP Parval NLST [**INSTANCES** NUMINST]]

Repeat Item 3 combined with the indicated repetitions of Item 4 NPRIV times. Items 3 and 4 are not read if NPRIV is negative or 0.

If PARNAM is to be a time-varying parameter, the keyword "INSTANCES" and a value for NUMINST must be entered.

4a. [INSTNAM]

4b. [Layer Row Column Stage Condfact Rbot [xyz]]

After each Item 3 for which the keyword "INSTANCES" is not entered, read Item 4b and not Item 4a.

After each Item 3 for which the keyword "INSTANCES" is entered, read Item 4a and Item 4b for each instance. NLST repetitions of Item 4b are required; they are read by subroutine ULSTRD. (SFAC of the ULSTRD utility subroutine applies to Condfact). The NLST repetitions of Item 4b follow each repetition of Item 4a when PARNAM is time varying.

FOR EACH STRESS PERIOD

5. ITMP NP

6. Layer Row Column Stage Cond Rbot [xyz]

ITMP repetitions of Item 6 are read by subroutine ULSTRD if ITMP > 0. (SFAC of the ULSTRD utility subroutine applies to Cond.) Item 6 is not read if ITMP is negative or 0.

7. [Pname [Iname]]

(Item 7 is repeated NP times. Item 7 is not read if NP is negative or 0. Iname is read if Pname is a time-varying parameter.)

Explanation of Variables Read by the RIV Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The "#" character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NPRIV—is the number of river parameters.

MXL—is the maximum number of river reaches that will be defined using parameters.

MXACTR—is the maximum number of river reaches in use during any stress period, including those that are defined using parameters.

IRIVCB—is a flag and a unit number.

If IRIVCB > 0, cell-by-cell flow terms will be written to this unit number when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

If IRIVCB = 0, cell-by-cell flow terms will not be written.

If IRIVCB < 0, river leakage for each reach will be written to the listing file when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

Option—is an optional list of character values.

"AUXILIARY abc" or "AUX abc"—defines an auxiliary variable, named "abc", which will be read for each river reach as part of Items 4 and 6. Up to 20 variables can be specified, each of which must be preceded by "AUXILIARY" or "AUX." These variables will not be used by the Ground-Water Flow Process Package, but they will be available for use by other processes. The auxiliary variable values will be read after the Rbot variable.

"CBCALLOCATE" or "CBC"—indicates that memory should be allocated to store cell-by-cell flow for each river reach in order to make these flows available for use in other packages.

PARNAM—is the name of a parameter. This name can consist of 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent.

PARTYP—is the type of parameter. For the RIV Package, the only allowed parameter type is RIV, which defines values of riverbed hydraulic conductance.

Parval—is the parameter value. This parameter value may be overridden by a value in the Parameter Value File.

NLST—is the number of river reaches in a non-time-varying parameter. For a time-varying parameter, NLST is the number of reaches in each instance.

INSTANCES—is an optional keyword that designates a parameter as time varying. The keyword is not case sensitive; that is, any combination of the same characters with different case will be equivalent. If **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, PARNAM is non-time-varying and NUMINST should not be present.

NUMINST—is the number of instances for a time-varying parameter, where each instance is a list of river reaches and associated properties. If the keyword **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, NUMINST should not be present.

INSTNAM—is the name of an instance associated with the parameter named in the corresponding Item 3. The instance name can be 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent. Instance names must be unique for a parameter, but instance names may be reused for different parameters.

Layer—is the layer number of the cell containing the river reach.

Row—is the row number of the cell containing the river reach.

Column—is the column number of the cell containing the river reach.

Stage—is the head in the river.

Condfact—is the factor used to calculate riverbed hydraulic conductance from the parameter value. The conductance is the product of Condfact and the parameter value.

Rbot—is the elevation of the bottom of the riverbed.

[xyz]—represents the values of the auxiliary variables for a river reach that have been defined in Item 2. The values of auxiliary variables must be present in each repetition of Items 4 and 6 if they are defined in Item 2. The values must be specified in the order used to define the variables in Item 2.

ITMP—is a flag and a counter.

If $ITMP < 0$, non-parameter river data from the last stress period will be reused.

If $ITMP \geq 0$, ITMP will be the number of non-parameter reaches read for the current stress period.

NP—is the number of parameters in use in the current stress period.

Cond—is the riverbed hydraulic conductance.

Pname—is the name of a parameter that is being used in the current stress period. NP parameter names will be read.

Iname—is an instance name that is read only if Pname is a time-varying parameter. Multiple instances of the same parameter are not allowed in a stress period.

Recharge Package

Input to the Recharge (RCH) Package is read from the file that has type "RCH" in the Name File. All single-valued variables are free format if the option "FREE" is specified in the Basic Package input file; otherwise, the non-optional variables have 10-character fields and the optional variables are free format.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. [**PARAMETER** NPRCH]

This optional item must start with the word "PARAMETER".

2. NRCHOP IRCHCB

3. [PARNAM PARTYP Parval NCLU [INSTANCES NUMINST]]

Repeat Item 3 combined with the indicated repetitions of Item 4 NPRCH times. Items 3 and 4 are not read if NPRCH is negative or 0.

If PARNAM is to be a time-varying parameter, the keyword "INSTANCES" and a value for NUMINST must be entered.

4a. [INSTNAM]

4b. [Mltarr Zonarr IZ]

After each Item 3 for which the keyword "INSTANCES" is not entered, read Item 4b and not Item 4a.

After each Item 3 for which the keyword "INSTANCES" is entered, read Item 4a and Item 4b for each instance. NCLU repetitions of Item 4b are required. Each repetition of Item 4b is called a parameter cluster. The NCLU repetitions of Item 4b follow each repetition of Item 4a when PARNAM is time varying.

FOR EACH STRESS PERIOD

5. INRECH INIRCH

6. [RECH(NCOL,NROW)] -- U2DREL if NPRCH=0 and if INRECH ≥ 0

7. [Pname [Iname] [IRCHPF]] -- if NPRCH > 0 and if INRECH > 0

Either Item 6 or Item 7 may be read, but not both. Item 7, if read, is repeated INRECH times. Iname is read if Pname is a time-varying parameter.

8. [IRCH(NCOL,NROW)] -- U2DINT If NRCHOP=2 and if INIRCH ≥ 0

Explanation of Variables Read by the RCH Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The "#" character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NPRCH—is the number of recharge parameters.

NRCHOP—is the recharge option code. Recharge fluxes are defined in a layer variable, RECH, with one value for each vertical column. Accordingly, recharge is applied to one cell in each vertical column, and the option code determines which cell in the column is selected for recharge.

- 1—Recharge is only to the top grid layer.
- 2—Vertical distribution of recharge is specified in layer variable IRCH.
- 3—Recharge is applied to the highest active cell in each vertical column. A constant-head node intercepts recharge and prevents deeper infiltration.

IRCHCB—is a flag and a unit number.

If $IRCHCB > 0$, cell-by-cell flow terms will be written to this unit number when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

If $IRCHCB \leq 0$, cell-by-cell flow terms will not be written.

PARNAM—is the name of a parameter to be defined. This name can consist of 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent.

PARTYP—is the type of parameter to be defined. For the RCH Package, the only allowed parameter type is RCH, which defines values of the recharge flux.

Parval—is the parameter value. This parameter value may be overridden by a value in the Parameter Value File.

NCLU—is the number of clusters required to define a non-time-varying parameter or one instance of a time varying parameter. Each repetition of Item 4b is a cluster (variables Mltarr, Zonarr, and IZ). Usually only one cluster is used to define a RCH non-time-varying parameter or an instance of a time-varying parameter; however, more than one cluster is acceptable.

INSTANCES—is an optional keyword that designates a parameter as time varying. The keyword is not case sensitive; that is, any combination of the same characters with different case can be used. If **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, PARNAM is non-time-varying and NUMINST should not be present.

NUMINST—is the number of instances for a time-varying parameter, where each instance is a list of river reaches and associated properties. If the keyword **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, NUMINST should not be present.

INSTNAM—is the name of an instance associated with the parameter named in the corresponding Item 3. The instance name can be 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent. Instance names must be unique for a parameter, but instance names may be reused for different parameters.

Mltarr—is the name of the multiplier array to be used to define cell values that are determined by a parameter. The name "NONE" means that there is no multiplier array, and the cell values will be set equal to Parval.

Zonarr—is the name of the zone array to be used to define the cells that are associated with a parameter. The name "ALL" means that there is no zone array, and all cells in the layer are associated with the parameter.

IZ—is up to 10 zone numbers (separated by spaces) that define the cells that are associated with a parameter. These values are not used if Zonarr is specified as "ALL." Values can be positive or negative, but 0 is not allowed. The end of the line, a zero value, or a non-numeric entry terminates the list of values.

INRECH—is the RECH read flag. Its function depends on whether or not parameters are being used.

If no parameters are being used ($NPRCH = 0$):

If $INRECH \geq 0$, a layer variable of recharge fluxes, RECH, is read.

If $INRECH < 0$, recharge rates from the preceding stress period are used.

If parameters are being used ($NPRCH > 0$):

If $INRECH > 0$, $INRECH$ is the number of parameters that will be used to define $RECH$ in the current stress period. Item 7 defines the names of the parameters.

If $INRECH < 0$, recharge parameters from the preceding stress period are used.

$INRECH = 0$ is not allowed. That is, when parameters are used, at least one parameter must be specified each stress period.

$INIRCH$ —is the $IRCH$ read flag, which is read only if $NRCHOP$ is two:

If $INIRCH \geq 0$, a layer variable of layer numbers ($IRCH$) is read.

If $INIRCH < 0$, the variable ($IRCH$) used in the preceding stress period is reused.

$RECH$ —is the recharge flux (LT^{-1}). Read only if $INRECH$ is greater than or equal to zero and if $NPRCH = 0$.

$Pname$ —is the name of a parameter that will be used to define the $RECH$ variable in the current stress period. Read $INRECH$ values if $NPRCH > 0$ and $INRECH > 0$.

$Iname$ —is an instance name that is read only if $Pname$ is a time-varying parameter. Multiple instances of the same parameter are not allowed in a stress period.

$IRCHPF$ —is an optional format code for printing the $RECH$ variable after it has been defined by parameters. The format codes are the same as those used in the $U2DREL$ array reading utility subroutine.

$IRCH$ —is the layer number variable that defines the layer in each vertical column where recharge is applied. Read only if $NRCHOP$ is two and if $INIRCH$ is greater than or equal to zero.

Well Package

Input to the Well (WEL) Package is read from the file that has type "WEL" in the Name File. Optional variables are shown in brackets. All variables are free format if the option "FREE" is specified in the Basic Package input file; otherwise, the non-optional variables have 10-character fields and the optional variables are free format.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. [**PARAMETER** NPWEL MXL]

This optional item must start with the word "PARAMETER".

2. MXACTW IWELCB [Option]

3. [PARNAM PARTYP Parval NLST [**INSTANCES** NUMINST]]

Repeat Item 3 combined with the indicated repetitions of Item 4 NPWEL times. Items 3 and 4 are not read if NPWEL is negative or 0.

If PARNAM is to be a time-varying parameter, the keyword "INSTANCES" and a value for NUMINST must be entered.

4a. [INSTNAM]

4b. Layer Row Column Qfact [xyz]

After each Item 3 for which the keyword "INSTANCES" is not entered, read Item 4b and not Item 4a.

After each Item 3 for which the keyword "INSTANCES" is entered, read Item 4a and Item 4b for each instance. NLST repetitions of Item 4b are required; they are read by subroutine ULSTRD. (SFAC of the ULSTRD utility subroutine applies to Qfact). The NLST repetitions of Item 4b follow each repetition of Item 4a when PARNAM is time varying.

FOR EACH STRESS PERIOD

5. ITMP NP

6. Layer Row Column Q [xyz]

(ITMP repetitions of Item 6 are read by subroutine ULSTRD if ITMP > 0. (SFAC of the ULSTRD utility subroutine applies to Q.) Item 6 is not read if ITMP is negative or zero.

7. [Pname [Iname]]

(Item 7 is repeated NP times. It is not read if NP is negative or 0. Iname is read if Pname is a time-varying parameter.)

Explanation of Variables Read by the WEL Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The "#" character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NPWEL—is the number of well parameters.

MXL—is the maximum number of wells that will be defined using parameters.

MXACTW—is the maximum number of wells in use during any stress period, including those that are defined using parameters.

IWELCB—is a flag and a unit number.

If IWELCB > 0, cell-by-cell flow terms will be written to this unit number when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

If IWELCB = 0, cell-by-cell flow terms will not be written.

If IWELCB < 0, well recharge for each well will be written to the listing file when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

Option—is an optional list of character values.

"AUXILIARY abc" or "AUX abc"—defines an auxiliary variable, named "abc", which will be read for each well as part of Items 4 and 6. Up to 20 variables can be specified, each of which must be preceded by "AUXILIARY" or "AUX." These variables will not be used by the Ground-Water Flow Process, but they will be available for use by other processes. The auxiliary variable values will be read after the Q variable.

"CBCALLOCATE" or "CBC"—indicates that memory should be allocated to store cell-by-cell flow for each well in order to make these flows available for use in other packages.

PARNAM—is the name of a parameter. This name can consist of 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent.

PARTYP—is the type of parameter. For the WEL Package, the only allowed parameter type is Q, which defines values of the volumetric recharge rate.

Parval—is the parameter value. This parameter value may be overridden by a value in the Parameter Value File.

NLST—is the number of wells in a non-time-varying parameter. For a time-varying parameter, NLST is the number of wells in each instance.

INSTANCES—is an optional keyword that designates a parameter as time varying. The keyword is not case sensitive; that is, any combination of the same characters with different case can be used. If **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, PARNAM is non-time-varying and NUMINST should not be present.

NUMINST—is the number of instances for a time-varying parameter, where each instance is a list of river reaches and associated properties. If the keyword **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, NUMINST should not be present.

INSTNAM—is the name of an instance associated with the parameter named in the corresponding Item 3. The instance name can be 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent. Instance names must be unique for a parameter, but instance names may be reused for different parameters.

Layer—is the layer number of the model cell that contains the well.

Row—is the row number of the model cell that contains the well.

Column—is the column number of the model cell that contains the well.

Qfact—is the factor used to calculate well recharge rate from the parameter value. The recharge rate is the product of Qfact and the parameter value.

[xyz]—represents the values of the auxiliary variables for a well that have been defined in Item 2. The values of auxiliary variables must be present in each repetition of Items 4 and 6 if they are defined in Item 2. The values must be specified in the order used to define the variables in Item 2.

ITMP—is a flag and a counter.

If $ITMP < 0$, non-parameter well data from the last stress period will be reused.

If $ITMP \geq 0$, ITMP will be the number of non-parameter wells read for the current stress period.

NP—is the number of parameters in use in the current stress period.

Q—is the volumetric recharge rate. A positive value indicates recharge and a negative value indicates discharge (pumping).

Pname—is the name of a parameter that is being used in the current stress period. NP parameter names will be read.

Iname—is an instance name that is read only if Pname is a time-varying parameter. Multiple instances of the same parameter are not allowed in a stress period.

Drain Package

Input to the Drain (DRN) Package is read from the file that has type "DRN" in the Name File. Optional variables are shown in brackets. All variables are free format if the option "FREE" is specified in the Basic Package input file; otherwise, the non-optional variables have 10-character fields and the optional variables are free format.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. [**PARAMETER** NPDRN MXL]

This optional item must start with the word "PARAMETER".

2. MXACTD IDRNCB [Option]

3. [PARNAM PARTYP Parval NLST [**INSTANCES** NUMINST]]

Repeat Item 3 combined with the indicated repetitions of Item 4 NPDRB times. Items 3 and 4 are not read if NPDRN is negative or 0.

If PARNAM is to be a time-varying parameter, the keyword "INSTANCES" and a value for NUMINST must be entered.

4a. [INSTNAM]

4b. [Layer Row Column Elevation Condfact [xyz]]

After each Item 3 for which the keyword "INSTANCES" is not entered, read Item 4b and not Item 4a.

After each Item 3 for which the keyword "INSTANCES" is entered, read Item 4a and Item 4b for each instance. NLST repetitions of Item 4b are required; they are read by subroutine ULSTRD. (SFAC of the ULSTRD utility subroutine applies to Condfact). The NLST repetitions of Item 4b follow each repetition of Item 4a when PARNAM is time varying.

FOR EACH STRESS PERIOD

5. ITMP NP

6. Layer Row Column Elevation Cond [xyz]

ITMP repetitions of Item 6 are read by subroutine ULSTRD if ITMP > 0. (SFAC of the ULSTRD utility subroutine applies to Cond.) Item 6 is not read if ITMP is negative or 0.

7. [Pname [Iname]]

(Item 7 is repeated NP times. Item 7 is not read if NP is negative or 0. Iname is read if Pname is a time-varying parameter.)

Explanation of Variables Read by the DRN Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The "#" character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NPDRN—is the number of drain parameters.

MXL—is the maximum number of drain cells that will be defined using parameters.

MXACTD—is the maximum number of drain cells in use during any stress period, including those that are defined using parameters.

IDRNCB—is a flag and a unit number.

If IDRNCB > 0, cell-by-cell flow terms will be written to this unit number when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

If IDRNCB = 0, cell-by-cell flow terms will not be written.

If IDRNCB < 0, drain leakage for each drain cell will be written to the listing file when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

Option—is an optional list of character values.

"AUXILIARY abc" or "AUX abc"—defines an auxiliary variable, named "abc", which will be read for each drain as part of Items 4 and 6. Up to 20 variables can be specified, each of which must be preceded by "AUXILIARY" or "AUX." These variables will not be used by the Ground-Water Flow Process, but they will be available for use by other processes. The auxiliary variable values will be read after the Cond variable.

CBCALLOCATE or CBC—indicates that memory should be allocated to store cell-by-cell flow for each drain in order to make these flows available for use in other packages.

PARNAM—is the name of a parameter. This name can consist of 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent.

PARTYP—is the type of parameter. For the DRN Package, the only allowed parameter type is DRN, which defines values of the drain hydraulic conductance.

Parval—is the parameter value. This parameter value may be overridden by a value in the Parameter Value File.

NLST—is the number of drain in a non-time-varying parameter. For a time-varying parameter, NLST is the number of drain cells in each instance.

INSTANCES—is an optional keyword that designates a parameter as time varying. The keyword is not case sensitive; that is, any combination of the same characters with different case can be used. If **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, PARNAM is non-time-varying and NUMINST should not be present.

NUMINST—is the number of instances for a time-varying parameter, where each instance is a list of river reaches and associated properties. If the keyword **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, NUMINST should not be present.

INSTNAM—is the name of an instance associated with the parameter named in the corresponding Item 3. The instance name can be 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent. Instance names must be unique for a parameter, but instance names may be reused for different parameters.

Layer—is the layer number of the cell containing the drain.

Row—is the row number of the cell containing the drain.

Column—is the column number of the cell containing the drain.

Elevation—is the elevation of the drain.

MODFLOW-2005 Input Instructions, revised 8-1-2013

Condfact—is the factor used to calculate drain hydraulic conductance from the parameter value. The conductance is the product of Condfact and the parameter value.

[xyz]—represents the values of the auxiliary variables for a drain that have been defined in Item 2. The values of auxiliary variables must be present in each repetition of Items 4 and 6 if they are defined in Item 2. The values must be specified in the order used to define the variables in Item 2.

ITMP—is a flag and a counter.

If $ITMP < 0$, non-parameter drain data from the last stress period will be reused.

If $ITMP \geq 0$, ITMP will be the number of non-parameter drains read for the current stress period.

NP—is the number of parameters in use in the current stress period.

Cond—is the hydraulic conductance of the interface between the aquifer and the drain.

Pname—is the name of a parameter that is being used in the current stress period. NP parameter names will be read.

Iname—is an instance name that is read only if Pname is a time-varying parameter. Multiple instances of the same parameter are not allowed in a stress period.

Evapotranspiration Package

Input to the Evapotranspiration (EVT) Package is read from the file that is type "EVT" in the Name File. All single-valued variables are free format if the option "FREE" is specified in the Basic Package input file; otherwise, the non-optional variables have 10-character fields and the optional variables are free format.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. [**PARAMETER** NPEVT]

This optional item must start with the word "PARAMETER".

2. NEVTOP IEVTCB

3. [PARNAM PARTYP Parval NCLU [INSTANCES NUMINST]]

Repeat Item 3 combined with the indicated repetitions of Item 4 NPEVT times. Items 3 and 4 are not read if NPEVT is negative or 0.

If PARNAM is to be a time-varying parameter, the keyword "INSTANCES" and a value for NUMINST must be entered.

4a. [INSTNAM]

4b. [Mltarr Zonarr IZ]

After each Item 3 for which the keyword "INSTANCES" is not entered, read Item 4b and not Item 4a.

After each Item 3 for which the keyword "INSTANCES" is entered, read Item 4a and Item 4b for each instance.

NCLU repetitions of Item 4b are required. Each repetition of Item 4 is called a parameter cluster. The NCLU repetitions of Item 4b follow each repetition of Item 4a when PARNAM is time varying.

FOR EACH STRESS PERIOD

5. INSURF INEVTR INEXDP INIEVT

6. [SURF(NCOL,NROW)] -- U2DREL If INSURF ≥ 0

7. [EVTR(NCOL,NROW)] -- U2DREL If NPEVT = 0 and if INEVTR ≥ 0

8. [Pname [Iname] [IEVTPF]] -- if NPEVT > 0 and if INEVTR > 0

Either Item 7 or Item 8 may be read, but not both. Item 8, if read, is repeated INEVTR times. Iname is read if Pname is a time-varying parameter.

9. [EXDP(NCOL,NROW)] -- U2DREL If INEXDP ≥ 0

10. [IEVT(NCOL,NROW)] -- U2DINT If NEVTOP = 2 and if INIEVT ≥ 0

Explanation of Variables Read by the EVT Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The "#" character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NPEVT—is the number of evapotranspiration parameters.

NEVTOP—is the evapotranspiration (ET) option code. ET variables (ET surface, maximum ET rate, and extinction depth) are specified in layer variables, SURF, EVTR, and EXDP, with one value for each vertical column. Accordingly, ET is calculated for one cell in each vertical column. The option codes determine the cell within a column for which ET will be calculated.

- 1—ET is calculated only for cells in the top grid layer.
- 2—The cell for each vertical column is specified by the user in variable IEVT.

IEVTCB—is a flag and a unit number.

If $IEVTCB > 0$, cell-by-cell flow terms will be written to this unit number when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

If $IEVTCB \leq 0$, cell-by-cell flow terms will not be written.

PARNAM—is the name of a parameter to be defined. This name can consist of 1 to 10 characters and is not case sensitive; that is, any combination of the same characters with different case will be equivalent.

PARTYP—is the type of parameter to be defined. For the EVT Package, the only allowed parameter type is EVT, which defines values of the maximum ET flux, variable EVTR.

Parval—is the parameter value. This parameter value may be overridden by a value in the Parameter Value File.

NCLU—is the number of clusters required to define a non-time-varying parameter or one instance of a time-varying parameter. Each repetition of Item 4b is a cluster (variables Mltarr, Zonarr, and IZ). Usually only one cluster is used to define an EVT non-time-varying parameter or an instance of a time-varying parameter; however, more than one cluster is acceptable.

INSTANCES—is an optional keyword that designates a parameter as time varying. The keyword is not case sensitive; that is, any combination of the same characters with different case can be used. If **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, PARNAM is non-time-varying and NUMINST should not be present.

NUMINST—is the number of instances for a time-varying parameter, where each instance is a list of river reaches and associated properties. If the keyword **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, NUMINST should not be present.

INSTNAM—is the name of an instance associated with the parameter named in the corresponding Item 3. The instance name can be 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent. Instance names must be unique for a parameter, but instance names may be reused for different parameters.

Mltarr—is the name of the multiplier array to be used to define the values that are determined by a parameter. The name "NONE" means that there is no multiplier array, and the values will be set equal to Parval.

Zonarr—is the name of the zone array to be used to define the cells that are associated with a parameter. The name "ALL" means that there is no zone array, and all cells are associated with the parameter.

IZ—is up to 10 zone numbers (separated by spaces) that define the cells that are associated with a parameter. These values are not used if Zonarr is specified as "ALL." Values can be positive or negative, but 0 is not allowed. The end of the line, a zero value, or a non-numeric entry terminates the list of values.

INSURF—is the ET surface (SURF) read flag.

If $INSURF \geq 0$, a layer variable containing the ET surface elevation (SURF) will be read.

If $INSURF < 0$, the ET surface from the preceding stress period will be reused.

INEVTR—is the EVTR read flag. Its function depends on whether or not parameters are being used.

If no parameters are being used ($NPEVT=0$):

If $INEVTR \geq 0$, a layer variable containing the maximum ET rate (EVTR) will be read.

If $INEVTR < 0$, the maximum ET rate from the preceding stress period will be reused.

If parameters are being used ($NPEVT>0$):

If $INEVTR > 0$, INEVTR is the number of parameters that will be used to define EVTR in the current stress period. Item 8 defines the names of the parameters.

If $INEVTR < 0$, EVTR parameters from the preceding stress period are used.

$INEVTR = 0$ is not allowed. That is, when parameters are used, at least one parameter must be specified each stress period

INEXDP—is the extinction depth (EXDP) read flag.

If $INEXDP \geq 0$, a layer variable containing the extinction depth (EXDP) will be read.

If $INEXDP < 0$, the extinction depth from the preceding stress period will be reused.

INIEVT—is the layer indicator (IEVT) read flag that is read only if the ET option (NEVTOP) is equal to two.

If $INIEVT \geq 0$, a layer variable containing the layer indicators (IEVT) will be read.

If $INIEVT < 0$, layer indicators used during the preceding stress period will be reused.

SURF—is the elevation of the ET surface. This variable is read only if $INSURF \geq 0$

EVTR—is the maximum ET flux [volumetric flow rate per unit area (LT^{-1})]. This variable is read only if $INEVTR \geq 0$ and if $NPEVT=0$. Contrary to the usual convention in MODFLOW, EVTR values should be specified as positive values even though they represent an outflow from the ground-water system.

Pname—is the name of a parameter that will be used to define the EVTR variable in the current stress period. Read INEVTR values if $NPEVT > 0$ and $INEVTR > 0$.

Iname—is an instance name that is read only if Pname is a time-varying parameter. Multiple instances of the same parameter are not allowed in a stress period.

IEVTPF—is an optional format code for printing the EVTR variable after it has been defined by parameters. The format codes are the same as those used in the U2DREL array reading utility subroutine.

EXDP—is the ET extinction depth. This variable is read only if $INEXDP \geq 0$.

IEVT—is the layer indicator variable. For each horizontal location, IEVT indicates the layer from which ET is removed. IEVT is read only if the ET option is equal to two and if $INIEVT \geq 0$.

General-Head Boundary Package

Input to the General-Head Boundary (GHB) Package is read from the file that has file type "GHB" in the Name File. Optional variables are shown in brackets. All variables are free format if the option "FREE" is specified in the Basic Package input file; otherwise, the non-optional variables have 10-character fields and the optional variables are free format.

FOR EACH SIMULATION

0. [#Text]
Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.
1. [**PARAMETER** NPGHB MXL]
This optional item must start with the word "PARAMETER".
2. MXACTB IGHBCB [Option]
3. [PARNAM PARTYP Parval NLST [**INSTANCES** NUMINST]]
Repeat Item 3 combined with the indicated repetitions of Item 4 NPGHB times. Items 3 and 4 are not read if NPGHB is negative or 0.
If PARNAM is to be a time-varying parameter, the keyword "INSTANCES" and a value for NUMINST must be entered.
- 4a. [INSTNAM]
- 4b. [Layer Row Column Bhead Condfact [xyz]]
After each Item 3 for which the keyword "INSTANCES" is not entered, read Item 4b and not Item 4a.
After each Item 3 for which the keyword "INSTANCES" is entered, read Item 4a and Item 4b for each instance. NLST repetitions of Item 4b are required; they are read by subroutine ULSTRD. (SFAC of the ULSTRD utility subroutine applies to Condfact). The NLST repetitions of Item 4b follow each repetition of Item 4a when PARNAM is time varying.

FOR EACH STRESS PERIOD

5. ITMP NP
6. Layer Row Column Bhead Cond [xyz]
ITMP repetitions of Item 6 are read by subroutine ULSTRD if ITMP > 0. (SFAC of the ULSTRD utility subroutine applies to Cond.) Item 6 is not read if ITMP is negative or 0.
7. [Pname [Iname]]
(Item 7 is repeated NP times. Item 7 is not read if NP is negative or 0. Iname is read if Pname is a time-varying parameter.)

Explanation of Variables Read by the GHB Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The "#" character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

NPGHB—is the number of general-head boundary parameters.

MXL—is the maximum number of general-head-boundary cells that will be defined using parameters.

MXACTB—is the maximum number of general-head boundary cells in use during any stress period, including those that are defined using parameters.

IGHBCB—is a flag and a unit number.

If IGHBCB > 0, cell-by-cell flow terms will be written to the unit number when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

If IGHBCB = 0, cell-by-cell flow terms will not be written.

If IGHBCB < 0, boundary leakage for each GHB cell will be written to the listing file when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control.

Option—is an optional list of character values.

“AUXILIARY abc” or “AUX abc”—defines an auxiliary variable, named "abc", which will be read for each general-head boundary as part of Items 4 and 6. Up to 20 variables can be specified, each of which must be preceded by "AUXILIARY" or "AUX." These variables will not be used by the Ground-Water Flow Process, but they will be available for use by other processes. The auxiliary variable values will be read after the Cond variable.

“CBCALLOCATE” or “CBC”—indicates that memory should be allocated to store cell-by-cell flow for each general-head boundary in order to make these flows available for use in other packages.

PARNAM—is the name of a parameter. This name can consist of 1 to 10 characters and is not case sensitive; that is, any combination of the same characters with different case will be equivalent.

PARTYP—is the type of parameter to be defined. For the GHB Package, the only allowed parameter type is GHB, which defines values of the general-head boundary hydraulic conductance.

Parval—is the parameter value. This parameter value may be overridden by a value in the Parameter Value File.

NLST—is the number of head-dependent boundaries in a non-time-varying parameter. For a time-varying parameter, NLST is the number of head-dependent boundaries in each instance.

INSTANCES—is an optional keyword that designates a parameter as time varying. The keyword is not case sensitive; that is, any combination of the same characters with different case can be used. If **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, PARNAM is non-time-varying and NUMINST should not be present.

NUMINST—is the number of instances for a time-varying parameter, where each instance is a list of river reaches and associated properties. If the keyword **INSTANCES** is present, it must be followed by a value for NUMINST. If **INSTANCES** is absent, NUMINST should not be present.

INSTNAM—is the name of an instance associated with the parameter named in the corresponding Item 3. The instance name can be 1 to 10 characters and is not case sensitive. That is, any combination of the same characters with different case will be equivalent. Instance names must be unique for a parameter, but instance names may be reused for different parameters.

Layer—is the layer number of the cell affected by the head-dependent boundary.

Row—is the row number of the cell affected by the head-dependent boundary.

Column—is the column number of the cell affected by the head-dependent boundary.

Bhead—is the boundary head.

Condfact—is the factor used to calculate hydraulic conductance from the parameter value. The conductance is the product of Condfact and the parameter value.

[xyz]—represents the values of the auxiliary variables for a boundary that have been defined in Item 2. The values of auxiliary variables must be present in each repetition of Items 4 and 6 if they are defined in Item 2. The values must be specified in the order used to define the variables in Item 2.

ITMP—is a flag and a counter.

If $ITMP < 0$, non-parameter GHB data from the preceding stress period will be reused.

If $ITMP \geq 0$, ITMP is the number of non-parameter general-head boundaries read for the current stress period.

NP—is the number of parameters in use in the current stress period.

Cond—is the hydraulic conductance of the interface between the aquifer cell and the boundary.

Pname—is the name of a parameter that is being used in the current stress period. NP parameter names will be read.

Iname—is an instance name that is read only if Pname is a time-varying parameter. Multiple instances of the same parameter are not allowed in a stress period.

Strongly Implicit Procedure Package

Input to the Strongly Implicit Procedure (SIP) Package is read from the file that is type "SIP" in the Name File. All numeric variables are free format if the option "FREE" is specified in the Basic Package input file; otherwise, all the variables have 10-character fields.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. MXITER NPARM

2. ACCL HCLOSE IPCALC WSEED IPRSIP

Explanation of Variables Read by the SIP Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The "#" character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

MXITER—is the maximum number of times through the iteration loop in one time step in an attempt to solve the system of finite-difference equations.

NPARM—is the number of iteration variables to be used. Five variables are generally sufficient.

ACCL—is the acceleration variable, which must be greater than zero and is generally equal to one. If a zero is entered, it is changed to one.

HCLOSE—is the head change criterion for convergence. When the maximum absolute value of head change from all nodes during an iteration is less than or equal to HCLOSE, iteration stops.

IPCALC—is a flag indicating where the seed for calculating iteration variables will come from.

0—the seed entered by the user will be used.

1—the seed will be calculated at the start of the simulation from problem variables.

WSEED—is the seed for calculating iteration variables. WSEED is always read, but is used only if IPCALC is equal to zero.

IPRSIP—is the printout interval for SIP. IPRSIP, if equal to zero, is changed to 999. The maximum head change (positive or negative) is printed for each iteration of a time step whenever the time step is an even multiple of IPRSIP. This printout also occurs at the end of each stress period regardless of the value of IPRSIP.

Preconditioned Conjugate-Gradient Package

Input to the Preconditioned Conjugate-Gradient (PCG) Package is read from the file that is type "PCG" in the Name File. All numeric variables are free format if the option "FREE" is specified in the Basic Package input file; otherwise, all the variables have 10-character fields.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. MXITER ITER1 NPCOND [IHCOFADD]

2. HCLOSE RCLOSE RELAX NBPOL IPRPCG MUTPCG DAMP

Explanation of Variables Read by the PCG Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The "#" character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

MXITER—is the maximum number of outer iterations. For a linear problem MXITER should be 1, unless more than 50 inner iterations are required, when MXITER could be as large as 10. A larger number (generally less than 100) is required for a nonlinear problem.

ITER1—is the number of inner iterations. For nonlinear problems, ITER1 usually ranges from 10 to 30; a value of 30 will be sufficient for most linear problems.

NPCOND—is the flag used to select the matrix conditioning method:

1—is for Modified Incomplete Cholesky (for use on scalar computers)

2—is for Polynomial (for use on vector computers or to conserve computer memory)

IHCOFADD—is a flag that determines what happens to an active cell that is surrounded by dry cells:

0—cell converts to dry regardless of HCOF value. This is the default, which is the way PCG2 worked prior to the addition of this option.

Not 0—cell converts to dry only if HCOF is 0 (no head-dependent stresses or storage terms)

HCLOSE—is the head change criterion for convergence, in units of length. When the maximum absolute value of head change from all nodes during an iteration is less than or equal to HCLOSE, and the criterion for RCLOSE is also satisfied, iteration stops.

RCLOSE—is the residual criterion for convergence, in units of cubic length per time. The units for length and time are the same as established for all model data. (See LENUNI and ITMUNI input variables in the Discretization File.) When the maximum absolute value of the residual at all nodes during an iteration is less than or equal to RCLOSE, and the criterion for HCLOSE is also satisfied, iteration stops.

For nonlinear problems, convergence is achieved when the convergence criteria are satisfied for the first inner iteration.

RELAX—is the relaxation parameter used with NPCOND = 1. Usually, RELAX = 1.0, but for some problems a value of 0.99, 0.98, or 0.97 will reduce the number of iterations required for convergence. RELAX is not used if NPCOND is not 1.

NBPOL—is used when NPCOND = 2 to indicate whether the estimate of the upper bound on the maximum eigenvalue is 2.0, or whether the estimate will be calculated. NBPOL = 2 is used to specify the value is 2.0; for any other value of NBPOL, the estimate is calculated. Convergence is generally insensitive to this NBPOL. NBPOL is not used if NPCOND is not 2.

IPRPCG—is the printout interval for PCG. IPRPCG, if equal to zero, is changed to 999. The maximum head change (positive or negative) and residual change are printed for each iteration of a time step whenever the time step is an even multiple of IPRPCG. This printout also occurs at the end of each stress period regardless of the value of IPRPCG.

MUTPCG—is a flag that controls printing of convergence information from the solver:

- 0—is for printing tables of maximum head change and residual each iteration
- 1—is for printing only the total number of iterations
- 2—is for no printing
- 3—is for printing only if convergence fails

DAMP—is the damping factor. This variable typically is set equal to one, which indicates no damping. A value less than 1 and greater than 0 causes damping.

Direct Solver Package

Input to the Direct Solver (DE4) Package is read from the file that is type "DE4" in the Name File. All numeric variables are free format.

FOR EACH SIMULATION

0. [#Text]

Item 0 is optional—"#" must be in column 1. Item 0 can be repeated multiple times.

1. ITMX MXUP MXLOW MXBW

2. IFREQ MUTD4 ACCL HCLOSE IPRD4

Explanation of Variables Read by the DE4 Package:

Text—is a character variable (199 characters) that starts in column 2. Any characters can be included in Text. The “#” character must be in column 1. Lines beginning with # are restricted to the first lines of the file. Text is written to the Listing File.

ITMX—is the maximum number of iterations each time step. Specify $ITMX = 1$ if iteration is not desired. Ideally, iteration would not be required for direct solution; however, iteration is necessary if the flow equation is nonlinear (see explanation for $IFREQ = 3$) or if computer precision limitations result in inaccurate calculations as indicated by a large water-budget error. For a nonlinear flow equation, each iteration is equally time consuming because $[A]$ (eq. 2-27) changes each iteration and Gaussian elimination is required after each change. This is called external iteration. For a linear equation, iteration is substantially faster because $[A]$ is changed at most once per time step; thus, Gaussian elimination is required at most once per time step. This is called internal iteration.

MXUP—is the maximum number of equations in the upper part of the equations to be solved. This value affects the amount of memory used by the DE4 Package. If specified as 0, the program will calculate MXUP as half the number of cells in the model, which is an upper limit. The actual number of equations in the upper part will be less than half the number of cells whenever no-flow and constant-head cells are indicated because flow equations are not formulated for these cells. The DE4 Package prints the actual number of equations in the upper part when it runs. The printed value can be used for MXUP in future runs to minimize memory usage.

MXLOW—is the maximum number of equations in the lower part of equations to be solved. This value affects the amount of memory used by the DE4 Package. If specified as 0, the program will calculate MXLOW as half the number of cells in the model, which is an upper limit. The actual number of equations in the lower part will be less than half the number of cells whenever no-flow and constant-head cells are included because flow equations are not formulated for these cells. The DE4 Package prints the actual number of equations in the lower part when it runs. The printed value can be used for MXLOW in future runs to minimize memory usage.

MXBW—is the maximum band width plus 1 of the $[AL]$ matrix. This value affects the amount of memory used by the DE4 Package. If specified as 0, the program will calculate MXBW as the product of the two smallest grid dimensions plus 1, which is an upper limit. The DE4 Package prints the actual band width plus 1 when it runs. The printed value can be used for MXBW in future runs to minimize memory usage.

IFREQ—is a flag indicating the frequency at which coefficients in [A] change. This affects the efficiency of solution; significant work can be avoided if the user knows that [A] remains constant all or part of the time.

IFREQ = 1 indicates that the flow equations are linear and that coefficients of simulated head for all stress terms are constant for all stress periods. To meet the linearity requirement, all model layers must be confined (which is specified in the Block-Centered Flow Package by setting LAYCON equal to 0 for all layers or in the Layer-Property Flow Package by setting LAYTYP equal to 0 for all layers), and formulations must not change based upon head (such as seepage from a river changing from head dependent flow to a constant flow when head drops below the bottom of the riverbed). Examples of coefficients of simulated head for stress terms are riverbed conductance, drain conductance, maximum evapotranspiration rate, evapotranspiration extinction depth, and general-head boundary conductance.

IFREQ = 2 indicates that the flow equations are linear as described for IFREQ=1, but coefficients of simulated head for some stress terms may change at the start of each stress period. Examples of coefficients of simulated head for stress terms are riverbed conductance, drain conductance, maximum evapotranspiration rate, evapotranspiration extinction depth, and general-head boundary conductance. For a simulation consisting of only one stress period, IFREQ = 2 has the same meaning as IFREQ = 1.

IFREQ = 3 indicates that a nonlinear flow equation is being solved, which means that some terms in [A] depend on simulated head. Examples of head-dependent terms in [A] are transmissivity for water-table layers, which is based on saturated thickness; flow terms for rivers, drains, and evapotranspiration if they convert between head dependent flow and constant flow; and the change in storage coefficient when a cell converts between confined and unconfined. When a nonlinear flow equation is being solved, external iteration ($ITMX > 1$) is normally required to accurately approximate the nonlinearities. Note that when nonlinearities caused by water-table calculations are part of a simulation, obvious signs may not be present in the output from a simulation that does not use external iteration to indicate that iteration is needed. In particular, the budget error may be acceptably small without iteration even though significant error in head exists because of nonlinearity. Additional information about this issue is contained in Chapter 7.

MUTD4—is a flag that indicates the quantity of information that is printed when convergence information is printed for a time step.

MUTD4 = 0 indicates that the number of iterations in the time step and the maximum head change each iteration are printed.

MUTD4 = 1 indicates that only the number of iterations in the time step is printed.

MUTD4 = 2 indicates no information is printed.

ACCL—is a multiplier for the computed head change for each iteration. Normally this value is 1. A value greater than 1 may be useful for improving the rate of convergence when using external iteration to solve nonlinear problems (IFREQ = 3). ACCL should always be 1 for linear problems. When $ITMX = 1$, ACCL is changed to 1 regardless of the input value; however, a value must always be specified.

HCLOSE—is the head change closure criterion. If iterating ($ITMX > 1$), iteration stops when the absolute value of head change at every node is less than or equal to HCLOSE. HCLOSE is not used if not iterating, but a value must always be specified.

IPRD4—is the time step interval for printing out convergence information when iterating ($ITMX > 1$). For example, if IPRD4 is 2, convergence information is printed every other time step. A value must always be specified even if not iterating.

Input Instructions for Array Reading Utility Subroutines

The array reading utility subroutines provide a common way for all packages to read variables that have multiple values. The term "array" is simply a programming term for a variable that contains multiple values. There are three subroutines: U2DREL, U2DINT, and U1DREL. U2DREL reads real two-dimensional variables, U2DINT reads integer two-dimensional variables, and U1DREL reads real one-dimensional variables. All of these subroutines work similarly. They read one array-control line and, optionally, a data array in a format specified on the array-control line. Several alternate structures for the control line are provided. The original fixed-format control lines work as documented in McDonald and Harbaugh (1988), and four free-format versions have been added. The free-format versions are described first because they are easier to use.

FREE-FORMAT CONTROL LINES FOR ARRAY READERS:

Values in bold italics are keywords that can be specified as uppercase or lowercase. Each control line is limited to a length of 199 characters.

1. ***CONSTANT*** CNSTNT
All values in the array are set equal to CNSTNT.
2. ***INTERNAL*** CNSTNT FMTIN IPRN
The individual array elements will be read from the same file that contains the control line.
3. ***EXTERNAL*** Nunit CNSTNT FMTIN IPRN
The individual array elements will be read from the file unit number specified by Nunit. The name of the file associated with this file unit must be contained in the Name File.
4. ***OPEN/CLOSE*** FNAME CNSTNT FMTIN IPRN
The array will be read from the file whose name is specified by FNAME. This file will be opened on unit 99 just prior to reading the array and closed immediately after the array is read. This file should not be included in the Name File. A file that is read using this control line can contain only a single array.

FIXED-FORMAT CONTROL LINE FOR ARRAY READERS:

A fixed-format control line contains the following variables:

LOCAT CNSTNT FMTIN IPRN

These variables are explained below. LOCAT, CNSTNT, and IPRN are 10-character numeric fields. For U2DREL and U1DREL, CNSTNT is a real number. For U2DINT, CNSTNT is an integer and must not include a decimal. FMTIN is a 20-character text field. All four variables are always read when the control line is fixed format; however, some of the variables are unused in some situations. For example when LOCAT = 0, FMTIN and IPRN are not used.

Explanation of Variables in the Control Lines:

CNSTNT—is a real-number constant for U2DREL and U1DREL, and an integer constant for U2DINT. If the array is being defined as a constant, CNSTNT is the constant value. If individual elements of the array are being read, the values are multiplied by CNSTNT after they are read. CNSTNT, when used as a multiplier and specified as 0, is changed to 1.

FMTIN—is the format for reading array elements. The format must contain 20 characters or less. The format must either be a standard Fortran format that is enclosed in parentheses, "(FREE)" which indicates free format, or "(BINARY)" which indicates binary (unformatted) data. When using a free-format control line, the format must be

enclosed in apostrophes if it contains one or more blanks or commas. A binary file that can be read by MODFLOW may be created in only two ways. The first way is to use MODFLOW to create the file by saving heads in a binary file. This is commonly done when the user desires to use computed heads from one simulation as initial heads for a subsequent simulation. The other way to create a binary file is to write a special program that generates a binary file, and compile this program using a Fortran compiler that is compatible with the compiler used to compile MODFLOW. "(FREE)" and "(BINARY)" can only be specified in free-format control lines. Also, "(BINARY)" can be specified only when using U2DREL or U2DINT, and only when the control line is EXTERNAL or OPEN/CLOSE. When the "(FREE)" option is used, be sure that all array elements have a non-blank value and that a comma or at least one blank separates adjacent values.

IPRN—is a flag that indicates whether the array being read should be written to the Listing File after the array has been read and a code for indicating the format that should be used when the array is written. The format codes are different for each of the three array-reading subroutines as shown below. IPRN is set to zero when the specified value exceeds those defined. If IPRN is less than zero, the array will not be printed.

IPRN	U2DREL	U2DINT	U1DREL
0	10G11.4	10I11	10G12.5
1	11G10.3	60I1	5G12.5
2	9G13.6	40I2	
3	15F7.1	30I3	
4	15F7.2	25I4	
5	15F7.3	20I5	
6	15F7.4	10I11	
7	20F5.0	25I2	
8	20F5.1	15I4	
9	20F5.2	10I6	
10	20F5.3		
11	20F5.4		
12	10G11.4		
13	10F6.0		
14	10F6.1		
15	10F6.2		
16	10F6.3		
17	10F6.4		
18	10F6.5		
19	5G12.5		
20	6G11.4		
21	7G9.2		

Nunit—is the unit for reading the array when the *EXTERNAL* free-format control line is used.

LOCAT—indicates the location of the array values for a fixed-format array control line. If LOCAT = 0, all elements are set equal to CNSTNT. If LOCAT > 0, it is the unit number for reading formatted lines using FMTIN as the format. If LOCAT < 0, it is the unit number for binary (unformatted) lines, and FMTIN is ignored. Also, when LOCAT is not 0, the array values are multiplied by CNSTNT after they are read.

Examples of Free-Format Control Lines

The following examples use free-format control lines for reading an array. The example array is a real array consisting of 4 rows with 7 columns per row:

```

CONSTANT  5.7          This sets an entire array to the value "5.7".

INTERNAL  1.0  (7F4.0)  3      This reads the array values from the
  1.2 3.7 9.3 4.2 2.2 9.9 1.0  file that contains the control line.
  3.3 4.9 7.3 7.5 8.2 8.7 6.6  Thus, the values immediately follow the
  4.5 5.7 2.2 1.1 1.7 6.7 6.9  control line.
  7.4 3.5 7.8 8.5 7.4 6.8 8.8

EXTERNAL 52  1.0  (7F4.0)  3  This reads the array from the formatted
                               file opened on unit 52.

EXTERNAL 47 1.0  (BINARY)  3  This reads the array from the
                               binary file opened on unit 47.

OPEN/CLOSE test.dat  1.0  (7F4.0)  3  This reads the array from the
                                       file named "test.dat".

```

Input Instructions for List Utility Subroutine (ULSTRD)

Subroutine ULSTRD reads lists that are any number of repetitions of an input item that contains multiple variables. Examples of packages that make use of this subroutine are the General-Head Boundary, Drain, River, and Well Packages.

Binary files can be read if they are EXTERNAL or OPEN/CLOSE as specified below. SFAC is not read for binary files. In Binary files the first list 3 values (layer, row, and column) must be Real numbers even though these values are actually Integers in the model. These values will be converted to Integers before use in the model. All auxiliary data must be included in the binary file.

1. [**EXTERNAL** IN] or [**OPEN/CLOSE** FNAME [(**BINARY**)]

If Item 1 is not included, then the list is read from the package file. Item 1 must begin with the keyword “EXTERNAL” or the keyword “OPEN/CLOSE” (not both)

2. [**SFAC** Scale]

3. List

Explanation of Variables Read by the List Utility Subroutine:

IN—is the unit number for a file from which the list will be read. The name of the file associated with this file unit must be contained in the Name File, and its file type must be “DATA” or “DATA(BINARY)” in the Name File. The file will be read as binary if the file type in the Name File is specified as “DATA(BINARY)”. SFAC is not read if the list is read from a binary file.

FNAME—is the name of a file from which the list will be read. This file will be opened on unit 99 just before reading the list and closed immediately after the list is read. This file should not be included in the Name File. The keyword “(BINARY)” can specified after FNAME to indicate that the file is binary. SFAC is not read if the list is read from a binary file.

Scale—is a scale factor that is multiplied times the value of one or more variables within every line of the list. The input instructions that define a list, which will be read by ULSTRD, should specify the variables to which SFAC applies. If Item 2 is not included, then Scale is 1.0. If Item 2 is included, it must begin with the keyword “SFAC.” The values of the list variables that are printed to the listing file include the effect of Scale. SFAC is not read if the list is read from a binary file.

List—is a specified number of lines of data in which each line contains a specified number of variables. The first three variables are always layer, row, and column. The other fields vary according to which package is calling this subroutine.