

## For Each Simulation

### 0. Data: [#Text]

Text A character variable (up to 199 characters) that is printed when the file is read. The “#” character must be in column 1, and, accordingly, the variable starts in column 2. Any characters can be included in Text.

Note 1: Item 0 can be repeated multiple times.

Options must be preceded with the "OPTIONS" specification and followed by the "END" specification. Letters can be specified as upper or lower case.

Optional character variables for UZF1 in any order, character variables must be preceded by “OPTIONS” and followed by “END.” Total number of lines includes the number of character variables plus 1 line for the word “OPTIONS” and 1 line for the word “END.”:

### 0B. Data: [Options Block]

OPTIONS

[SPECIFYTHTR]

[SPECIFYHTI]

[NOSURFLEAK]

[SPECIFYSURFK]

[REJECTSURFK]

[SEEPSURFK]

[ETSQUARE smoothfact]

[CAPILLARYUZET]

[NETFLUX unitrech unitdis]

END

SPECIFYSURFK -- An optional character variable. When SPECIFYSURFK is specified, the variable SURFK is specified in Data Set 4b.

REJECTSURFK -- An optional character variable. When REJECTSURFK is specified, variable SURFK instead of VKS is used to calculate rejected infiltration. REJECTSURFK is included only if SPECIFYSURFK is included.

SEEPSURFK -- An optional character variable. When SEEPSURFK is specified, variable SURFK instead of VKS is used to calculate surface leakage. SEEPSURFK is included only if SPECIFYSURFK is included.

ETSQUARE -- An optional character variable. When ETSQUARE is specified, groundwater ET is simulated using a constant potential ET rate, and is smoothed over a specified smoothing interval. This option is recommended only when using the NWT solver.

smoothfact -- An optional real variable specified if ETSQUARE is specified. For example, if the interval factor (smoothfact) is specified as smoothfact = 0.1 (recommended value), then the smoothing interval will be calculated as:  $SMOOTHINT = 0.1 * EXTDP$  and is applied over the range for groundwater head (h):

$h < CELTOP - EXTDP$ , ET is zero;

$CELTOP - EXTDP < h < CELTOP - EXTDP + SMOOTHINT$ , ET is smoothed; and

$CELTOP - EXTDP + SMOOTHINT < h$ , ET is equal to potential ET.

CAPILLARYUZET -- An optional character variable. When CAPILLARYUZET is specified, unsaturated zone ET is calculated using an alternate formulation (Niswonger, 2020). For this option, 3 additional variables are required in the stress period data for simulating ET, including AIR\_ENTRY, H\_ROOT, and ROOTACT. See input for stress periods below for details.

NETFLUX -- An optional character variable. When NETFLUX is specified, the sum of recharge (units of cubic length per time) and the sum of discharge (units of cubic length per time) is written to separate unformatted files using module UBDSV3.

Unitrech and Unitdis are the unit numbers to which these values are written when "SAVE BUDGET" is specified in Output Control. Values written to Unitrech are the sum of recharge values for the UZF, SFR2, and LAK Packages, and values written to Unitdis are the sum of discharge values for the UZF, SFR2, and LAK Packages. Values are averaged over the period between output times.

## **1. Data: NUZTOP IUZFOPT IRUNFLG IETFLG IUZFCB1 IUZFCB2 NTRAIL2 NSETS2 NUZGAG SURFDEP**

NUZTOP An integer value used to define which cell in a vertical column that recharge and discharge is simulated.

- 1 Recharge to and discharge from only the top model layer. This option assumes land surface is defined as top of layer 1.
- 2 Recharge to and discharge from the specified layer in variable IUZFBND. This option assumes land surface is defined as top of layer specified in IUZFBND.
- 3 Recharge to and discharge from the highest active cell in each vertical column. Land surface is determined as top of layer specified in IUZFBND. A constant head node intercepts any recharge and prevents deeper percolation. Appendix 1 29

4 Values of IUZFBND are used to define the top of the unsaturated zone, and recharge is added to the uppermost layer in a column that contains a water table. The layer to which recharge is added is updated at the beginning of each new time step and is held constant during a time step.

IUZFOPT An integer value equal to 0, 1, or 2. A value of zero indicates that flow will not be routed through the unsaturated zone, rather infiltration will be applied directly to the saturated zone. A value of 1 indicates that the vertical hydraulic conductivity will be specified within the UZF1 Package input file using array VKS. A value of 2 indicates that the vertical hydraulic conductivity will be specified within either the BCF, LPF or UPW Package input file.

IRUNFLG An integer value that specifies whether ground water that discharges to land surface will be routed to stream segments or lakes as specified in the IRUNBND array (IRUNFLG not equal to zero) or if ground-water discharge is removed from the model simulation and accounted for in the ground-water budget as a loss of water (IRUNFLG=0). The Streamflow-Routing (SFR2) and/or the Lake (LAK3) Packages must be active if IRUNFLG is not zero.

IETFLG An integer value that specifies whether or not evapotranspiration (ET) will be simulated. ET will not be simulated if IETFLG is zero, otherwise it will be simulated.

IUZFCB1 An integer value used as a flag for writing ground-water recharge, ET, and ground-water discharge to land surface rates to a separate unformatted file using subroutine UBUDSV. If IUZFCB1>0, it is the unit number to which the cell-by-cell rates will be written when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control. If IUZFCB1 ≤ 0, cell-by-cell rates will not be written to a file.

IUZFCB2 An integer value used as a flag for writing ground-water recharge, ET, and ground-water discharge to land surface rates to a separate unformatted file using module UBDSV3. If IUZFCB2>0, it is the unit number to which cell-by-cell rates will be written when "SAVE BUDGET" or a non-zero value for ICBCFL is specified in Output Control. If IUZFCB2≤0, cell-by-cell rates will not be written to file.

NTRAIL2 An integer value equal to the number of trailing waves used to define the water-content profile following a decrease in the infiltration rate. The number of trailing waves varies depending on the problem, but a range between 10 and 20 is usually adequate. More trailing waves may decrease mass-balance error and will increase computational requirements and memory usage. This variable is not specified if IUZFOPT is zero or less.

NSETS2 An integer value equal to the number of wave sets used to simulate multiple infiltration periods. The number of wave sets should be set to 20 for most problems involving time varying infiltration. The total number of waves allowed within an unsaturated zone cell is equal to NTRAIL2\*NSETS2. An error will occur if the number of waves in a cell exceeds this value. This variable is not specified if IUZFOPT is zero or less.

NUZGAG An integer value equal to the number of cells (one per vertical column) that will be specified for printing detailed information on the unsaturated zone water budget and water content. A gage also may be used to print the budget summed over all model cells.

SURFDEP A real value equal to the average undulation depth within a finite-difference cell.

Note 2: The variables NTRAIL2 and NSETS2 are used for dimensioning arrays.

**2. Data: [IUZFBND (NCOL, NROW)] -- U2DINT**

IUZFBND An array of integer values used to define the aerial extent of the active model in which recharge and discharge will be simulated. If IRUNFLG > 0: Read item 3

**3. Data: [IRUNBND (NCOL, NROW)] -- U2DINT**

IRUNBND An array of integer values used to define the stream segments within the Streamflow-Routing (SFR2) Package or lake numbers in the Lake (LAK3) Package that overland runoff from excess infiltration and ground-water discharge to land surface will be added. A positive integer value identifies the stream segment and a negative integer value identifies the lake number. 30 Documentation of the Unsaturated-Zone Flow Package

IF IUZOPT = 1: Read item 4.

**4. Data: [VKS (NCOL, NROW)] -- U2DREL**

VKS An array of positive real values used to define the saturated vertical hydraulic conductivity of the unsaturated zone (LT-1). Note 3: Vertical hydraulic conductivity is optional when either the LPF, UPW, or BCF Package is used to define vertical hydraulic conductivity of cells (IUZFOPT=2).

If keyword SPECIFYSURFK is specified

**4B. DATA [SURFK (NCOL, NROW)] -- U2DREL**

SURFK An array of positive real values used to define the hydraulic conductivity (units of length per time). SURFK is used for calculating the rejected infiltration and/or surface leakage. If SURFK is set greater than VKS, then it is set equal to VKS.

**5. Data: [EPS (NCOL, NROW)] -- U2DREL**

EPS An array of positive real values for each model cell used to define the Brooks-Corey epsilon of the unsaturated zone. Epsilon is used in the relation of water content to hydraulic conductivity (Brooks and Corey, 1966). This variable is not specified if IUZFOPT is zero or less.

If the character variable SPECIFYTHTR is specified in the options block, then items 5B is specified.

**5B. Data: [THTR (NCOL, NROW)] -- U2DREL**

THTR An array of positive real values for each model cell used to define the Brooks-Corey residual water content of the unsaturated zone. THTR is used in the relation of water content to hydraulic conductivity (Brooks and Corey, 1966). This variable is not specified if IUZFOPT is zero or less.

**6. Data: [THTS (NCOL, NROW)] -- U2DREL**

THTS An array of positive real values used to define the saturated water content of the unsaturated zone in units of volume of water to total volume (L3 L-3). This variable is not specified if IUZFOPT is zero or less.

**7. Data: [THTI (NCOL, NROW)] -- U2DREL**

**THTI** An array of positive real values used to define the initial water content for each vertical column of cells in units of volume of water at start of simulation to total volume (L3 L-3). THTI should not be specified for simulations that start with a steady state stress period, unless the character variable SPECIFYTHTI is included in the OPTIONS block. This variable is not specified if IUZFOT is zero or less.

If NUZGAG>0: Item 8 is repeated NUZGAG times

## **8. Data: [IUZROW] [IUZCOL] IFTUNIT [IUZOPT]**

**IUZROW** An integer value equal to the row number of the cell that unsaturated-zone information will be printed for each time step. The variable is not used when IFTUNIT is negative.

**IUZCOL** An integer value equal to the column number of the cell that unsaturated-zone information will be printed for each time step. The variable is not used when IFTUNIT is negative.

**IFTUNIT** An integer value equal to the unit number of the output file. A positive value is for output of individual cells whereas a negative value is for output that is summed over all model cells. The summed output includes applied infiltration, runoff, actual infiltration, ground-water discharge to land surface, ET from the unsaturated zone, ET from ground water, recharge, and change in unsaturated-zone storage.

**IUZOPT** An integer value that is a flag for the type of expanded listing desired in the output file. The variable is not used when IFTUNIT is negative.

- 1 Prints time, ground-water head, and thickness of unsaturated zone, and cumulative volumes of infiltration, recharge, storage, change in storage and ground-water discharge to land surface.
- 2 Same as option 1 except rates of infiltration, recharge, change in storage, and ground-water discharge also are printed.
- 3 Prints time, ground-water head, thickness of unsaturated zone, followed by a series of depths and water contents in the unsaturated zone. This option cannot be used when IUZFOT is zero or less.

Note 4: Item 8 must include exactly NUZGAG lines (records) of data. If NUZGAG > 1, it is permissible to repeat the same cell if a summary of volumes and rates and water contents are desired for a given cell. The records within item 8 can be listed in any order.

Note 5: A unique unit number for IFTUNIT must be specified for each line or record in item 8 and each number must match that used in the MODFLOW name file as Ftype "DATA" file types and file names (see Harbaugh, 2005).

## **For Each Stress Period**

### **9. Data: NUZF1**

**NUZF1** An integer value for reusing or reading infiltration rates that can change each stress period. If NUZF1 > 0, then infiltration rates at land surface are specified. If NUZF1 < 0, then infiltration rates from the previous stress period are used.

If NUZF1 > 0:

**10. Data: [FINF (NCOL, NROW)] – U2DREL**

FINF                    An array of positive real values used to define the infiltration rates (LT-1) at land surface for each vertical column of cells.

Note 6: If FINF is specified as being greater than the vertical hydraulic conductivity then FINF is set equal to the vertical unsaturated hydraulic conductivity. Excess water is routed to streams or lakes when IRUNFLG is not zero, and if SFR2 or LAK3 is active.

If IETFLG > 0: Read Items 11 through 16

**11. Data: NUZF2**

NUZF2                    An integer value for reusing or reading ET demand rates that can change each stress period. If NUZF2>0, then ET demand rates are specified.

If NUZF2>0:

**12. Data: [PET (NCOL, NROW)] – U2DREL**

PET                    An array of positive real values used to define the ET demand rates (L1 T-1) within the ET extinction depth interval for each vertical column of cells.

**13. Data: NUZF3**

NUZF3                    An integer value for reusing or reading ET extinction depths that can change each stress period. If NUZF3>0, then ET extinction depths are specified.

If NUZF3>0:

**14. Data: [EXTDP (NCOL, NROW)] – U2DREL**

EXTDP                    An array of positive real values used to define the ET extinction depths.

Note 7: The quantity of ET removed from a cell is limited by the volume of water stored in the unsaturated zone above the extinction depth. If ground water is within the ET extinction depth, then the rate removed is based on a linear decrease in the maximum rate at land surface and zero at the ET extinction depth. The linear decrease is the same method used in the Evapotranspiration Package (McDonald and Harbaugh, 1988, chap. 10).

**15. Data: NUZF4**

NUZF4                    An integer value for reusing or reading the extinction water content that can change each stress period. If NUZF4>0, then extinction water contents are specified.

If NUZF4>0:

**16. Data: [EXTWC (NCOL, NROW)] – U2DREL**

EXTWC            An array of positive real values used to define the extinction water content below which ET cannot be removed from the unsaturated zone. This variable is not specified if IUZFOPT is zero or less. Note 8: EXTWC must have a value between (THTS-Sy) and THTS, where Sy is the specific yield specified in either the LPF or BCF Package.

If the character variable CAPILLARYUZET is specified in the options block, then items 17-22 are specified.

**17. Data: [NUZF5]**

NUZF5            An integer value for reusing or reading the air entry pressure that can change each stress period.

If NUZF5>0, then air entry pressure values are specified.

**18. Data: [AIR\_ENTRY (NCOL, NROW)] – U2DREL**

AIR\_ENTRY        An array of positive real values used to define the Brooks-Corey air-entry pressure variable for calculating capillary pressure that is used in the unsaturated zone.

**19. Data: [NUZF6]**

NUZF6            An integer value for reusing or reading the root pressure that can change each stress period.

If NUZF6>0, then root pressure values are specified.

**20. Data: [H\_ROOT (NCOL, NROW)] – U2DREL**

H\_ROOT            An array of positive real values that are the root pressures used for simulating ET in the unsaturated zone.

**21. Data: [NUZF7]**

NUZF7            An integer value for reusing or reading the root pressure that can change each stress period.

If NUZF7>0, then root activity values are specified.

**22. Data: [ROOTACT (NCOL, NROW)] – U2DREL**

ROOTACT          An array of positive real values that are the root activity values used for simulating ET in the unsaturated zone.