**MODFLOW Packages**

Changes to SFR2, UZF1, and LAK7 for MODFLOW version ### is based on MODFLOW-NWT version 1.1.2. Changes made to MODFLOW-NWT are described in the release notes; users are encouraged to review those release notes in addition to the notes provided below.

**This release provides support for the new transport model called MT3D-USGS. Changes to MODFLOW-NWT to support MT3D-USGS were made to the source file lmt8\_NWT.f. These changes include writing output for the UZF, SFR2, and LAK7 Packages that is required for simulating transport in the unsaturated zone, streams, and lakes. Refer to the MT3D-USGS documentation report for details (Bedekar, V., Morway, E.D., Langevin, C.D., Tonkin, M.T., 2015, MT3D-USGS version 1: a U.S. Geological Survey release of MT3DMS updated with new and expanded transport capabilities for MODFLOW: U.S. Geological Survey Techniques and Methods 6-A53, variously paginated).**

**Source files that were modified for this release are: gwf2uzf1\_NWT.f, gwfuzfmodule\_NWT.f, gwf2sfr7\_NWT.f,gwfsfrmodule\_NWT.f,gwf2lak7\_NWT.f, NWT1\_gmres.f90, gwf2swr7.f, gwf2swr7util.f, gwf2mnw27\_NWT.f, gmres.f90, NWT1\_solver.f and NWT1\_xmd.f, and lmt8\_NWT.f.**

**Streamflow-Routing (SFR2) Package:**

**09/15/2016**

(1) The input format for specifying character-variable options has changed. Rather than specifying character-variable options in a single line in a particular order, each character-variable option is specified on a separate line in any order. If additional input is required along with the character-variable option, then this value is specified on the same line as the character-variable option separated by one or more spaces. For the new input format, options must be proceeded with the "OPTIONS" specification and followed by the "END" specification. Characters can be specified as upper or lower case. Previous input formats for SFR2 are supported.

Optional character variables for SFR2 in any order:

OPTIONS

[REACHINPUT]

[TRANSROUTE]

[TABFILES Numtab Maxval]

[LOSSFACTOR Factor]

END

New Data Set 1C:

[LOSSFACTOR Factor]

Definitions for new character-variable option:

LOSSFACTOR -- An optional character variable. When LOSSFACTOR is specified, the real variable Factor is mulitplied by STRHC1 or Hc1fact and Hc2fact to calculate seepage loss from streams. Calculation of groundwater seepage to streams is unchanged.

(2) Other changes: Some variables in the SFR2 Package were initialized; some variables were changed to arrays for use in MT3D-USGS; and an access violation was fixed.

Changes made to SFR2 for MODFLOW-NWT Version 1.0.9 07/01/2014:

A bug was fixed to avoid a memory-allocation error that occurred when using the tabfile option for models with more tabfiles than stream segments. Also, an uninitialized variable was initialized.

**Unsaturated-Zone Flow (UZF) Package:**

(1) Some variables in the UZF Package for calculating runoff were initialized; a minor bug was corrected that relates to simulating unsaturated-zone flow beneath lakes; and a floating-point exception was fixed.

(2) A new function was added for simulating groundwater evapotranspiration (ET). This function simulates a constant ET rate over the extinction depth rather than linearly reducing ET as groundwater head decreases. The ET is smoothly reduced to zero using the same polynomial function used to reduce pumping in drying cells (Niswonger and others, 2011). ET is smoothly reduced as groundwater head drops to the extinction depth. The smoothing interval is specified as a factor of the extinction depth.

(3) New Options were added to UZF1 to allow the hydraulic conductivity used to calculate rejected infiltration and surface leakage to be different than the vertical hydraulic conductivity of the unsaturated zone (VKS).

(4) The input format for specifying character-variable options has changed. Rather than specifying character-variable options in a single line in a particular order, each character-variable option is specified on a separate line in any order. If additional input is required along with the character-variable option, then this value is specified on the same line as the character-variable option separated by one or more spaces. For this new input format, options must be proceeded with the "OPTIONS" specification and followed by the "END" specification. Letters can be specified as upper or lower case. Previous input formats for UZF1 are supported.

Optional character variables for UZF1 in any order:

OPTIONS

[SPECIFYTHTR]

[SPECIFYTHTI]

[NOSURFLEAK]

[SPECIFYSURFK]

[REJECTSURFK]

[SEEPSURFK]

[ETSQUARE smoothfact]

[NETFLUX unitrech unitdis]

END

Definitions of new variables:

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.

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.

Data Set 4B:

[SURFK (NCOL, NROW)] -- U2DREL

SURFK -- An optional 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.

Changes made to UZF1 for MODFLOW-NWT version 1.0.9 07/01/2014

A bug was fixed to correct the applied infiltration rate as printed to the UZF1 gage output file summed over the entire model. Previous versions did not include applied infiltration rates in excess of VKS. This bug did not affect calculations or solutions made by UZF, rather only the values for applied infiltration written to UZF1 gage output summed over the entire model were affected.

Changes made to UZF1 for MODFLOW-NWT version 1.0.8 09/24/2013

A bug was fixed to allow the vertical hydraulic conductivity to be read when

IUZFOPT=-1; that is, when unsaturated-zone storage is ignored and infiltrated water is added directly to the water table.

The maximum root depth was reduced from extending through 99% of the cell thickness to 90% of the cell thickness. This improves convergence for models where the root depth extends to the bottom of the cell.

Initialization was added for a few variables and checks were added for divide by zero.

**Lake (LAK) Package:**

Some variables were changed to arrays in order to save data for MT3D-USGS. A minor bug was corrected that relates to simulating unsaturated-zone flow beneath lakes.

Changes made to LAK for MODFLOW-NWT version 1.0.9 07/01/2014

Fixed compact budget for outputting lake seepage. A small change was made that sets layer indices for calculating lakebed conductance.

Changes made to LAK for MODFLOW-NWT version 1.0.8 09/24/2013

A bug was fixed to correctly print lake seepage to unformatted budget files. This bug affects models with lake cells that are surrounded by inactive groundwater cells in the same lake.