Changes to the UZF package for release version 1.3; 6-20-07

The calculation was changed for simulating head-dependent recharge and discharge when the ground-water head is near or above land surface. The approach conceptualizes land surface as an undulating surface that represents variations in land surface altitude within the area of a single MODFLOW cell. The average height of undulations, D, in the land surface altitude is set to 1.0 internally within UZF to avoid changing the UZF input requirements; however, D (UZF program variable `SURFDEP`) can be changed within the UZF source code file gwf2uzf1.f. If the source file gwf2uzf1.f is changed then the program must be recompiled. This approach for simulating recharge and discharge reduces the iterations required for convergence and allows a smooth transition between a recharging and discharging condition.

Ground-water recharge

The specified infiltration (i.e. UZF input file variable `FINF`; Niswonger and others, 2006, p. 32) is applied to the saturated zone instead of the unsaturated zone if the ground-water head is above land surface (i.e. Discretization file input variable `TOP`; Harbaugh, p. 8-11) minus one-half the undulation depth, D (fig. 1). The units of the undulation depth are the same as those specified by variable `LENUNI` in the Discretization File. Recharge to the saturated zone decreases as a function of ground-water head, often called rejected recharge, and is calculated according to:

$$
\begin{aligned}
q &= 0 && h^{n-1} > TOP + 0.5D \\
q &= \frac{FINF}{D}\left[h^{n} - (TOP - 0.5D)\right] && TOP - 0.5D \le h^{n-1} \le TOP + 0.5D \\
q &= FINF && TOP - 0.5D > h^{n-1}
\end{aligned}
$$

where

q is the recharge, in length per time;

$FINF$ is the infiltration rate applied to the finite-difference cell, in length per time;

h^n is the ground-water head for time step m and iteration *n*, in length;

h^{n-1} is the ground-water head for time step m and iteration *n-1*, in length;

D is the undulation depth along land surface within the finite-difference cell, in length; and

TOP is the altitude of land surface, in length.

Ground-water discharge

Ground-water discharge to land surface is computed as:

$$Q = CND\left(h^n - (TOP - 0.5D)\right)$$

$$CND = \frac{K_v A_{fdc}}{0.5celthkD}\left(h^{n-1} - TOP + 0.5D\right) \qquad TOP - 0.5D < h^{n-1}$$

$$CND = 0 \qquad TOP - 0.5D \geq h^{n-1}$$

where

CND is the conductance across land surface, in length squared per time;

K_v is the vertical hydraulic conductivity of the unsaturated zone, in length per time;

celthk is the thickness of the model cell, in length;

Q is the volumetric-flow rate of water that discharges from ground water to land surface, in length cubed per time.

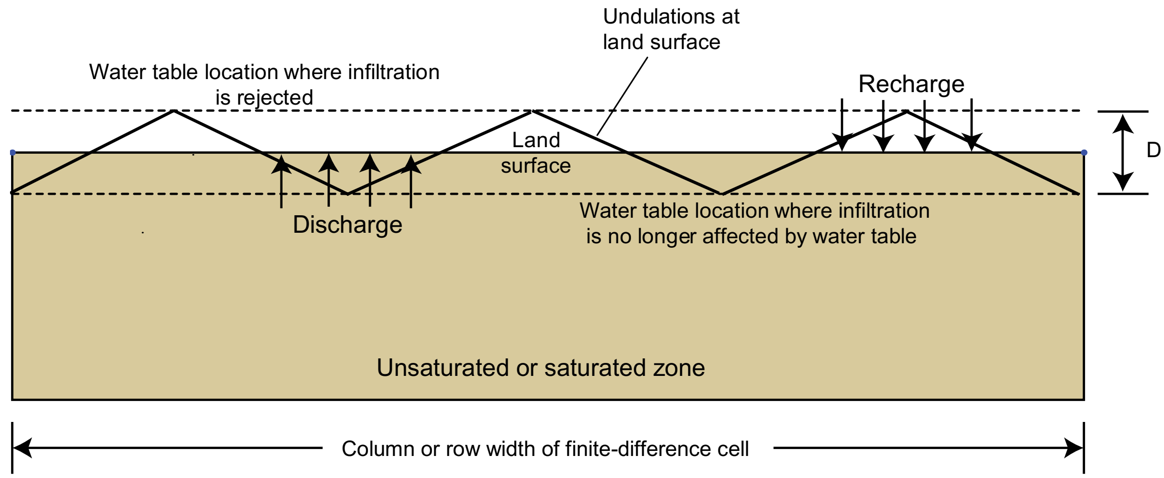

Figure 1. The effect of undulation depth, D, at land surface on ground-water recharge and discharge in relation to the water table in a finite-difference cell.

References

Niswonger, R.G., Prudic, D.E., and Regan, R.S., 2006, Documentation of the Unsaturated-Zone Flow (UZF1) Package for modeling unsaturated flow between the land surface and the water table with MODFLOW-2005: U.S. Geological Survey Techniques and Methods Book 6, Chapter A19, 62 p.

Harbaugh, A.W., 2005, MODFLOW-2005, the U.S. Geological Survey modular ground-water model-the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16, variously paginated.