*24. After you start working at Realenwelt Consulting, you are asked to construct a numerical model of flow in an agricultural field. The aquifer, which is next to a stream, is unconfined and heterogeneous; the alluvium near the stream has a conductivity of $K_A = 1\, \text{m/d}$ and an effective porosity of $n_A = 0.3$, while the soil farther from the stream has a conductivity of $K_s = 0.3\, \text{m/d}$ and an effective porosity of $n_s = 0.25$. An old tile drain was installed 20 m away from the stream many years ago, but after several years of drought, the field (but not the buffer strip) is irrigated at a rate of 5 mm/d.

   a. At this irrigation rate, does any water enter the drain?

   b. Fertilizer applied to the field might cause nutrients to enter the stream. The nutrient concentration will depend on the time the water remains in the soil. Use your numerical solution to compute the time to travel from the edge of the field to the stream. (Hint: Apply the formula we have used between cells in your model and add the times.)
25. Set up and run the sample problem for PMWIN. Follow the instructions in chapter 2 of *Processing Modflow* at least up to and including step 4. For this problem you will be most concerned with the volume of water out of the region (Table 2.2).

   a. Verify that you can reproduce the results in Table 2.2 on p. 18 of the documentation.

   b. Explain as many numbers in the table as you can. Try turning off the well and verify that the flow through the constant head boundary is correct.

26. Consider a confined aquifer of thickness 5 m, length 600 m, width 400 m, and hydraulic conductivity 25 m/d. The western boundary has a head of 10 m, and the eastern boundary has a head of 9 m. No flow occurs across the northern and southern boundaries. A well in the center of the aquifer pumps at 30 m$^3$/d.

   a. Solve this problem with PMWIN (Modflow) and obtain the water balance table as in Table 2.2 of the PMWIN documentation.

   b. Solve this problem in Excel and compute the flow across the eastern boundary. Compare to the result from Modflow.

   c. Plot contours of the piezometric head and streamlines and explain your plots.

27. A pump test was conducted in a 25-m thick, confined aquifer in which the initial piezometric surface was at elevation 15 m. The well was pumped at 30 L/s, and after one day the piezometric levels at distances of 35, 75, 110, and 150 m from the well were 14.1, 14.4, 14.7, and 14.9 m, respectively.

   a. Estimate the transmissivity and the hydraulic conductivity of the aquifer.

   b. Aquifers with transmissivity less than 10 m$^2$/d can supply only enough water for domestic wells and other low-yield uses (Lehr et al. 1988; Chin 2000, p. 501). How does this aquifer’s transmissivity compare to that value?

   c. Estimate the radius of influence of the well.

28. A pump test was conducted in an unconfined aquifer of saturated thickness 15 m (in the absence of pumping). The well was pumped at 8000 m$^3$/d, and after one day the drawdowns at 50 m and 100 m from the well were 0.42 m and 0.27 m, respectively.

   a. Show that in steady state the hydraulic conductivity can be computed from

\[
K = \frac{1}{\pi} \frac{Q_0 \ln(r_2/r_1)}{(H - s_2)^2 - (H - s_1)^2},
\]

where $Q_0$ is the pumping rate, $H$ is the saturated thickness in the absence of pumping, and $s_i$ is the drawdown at radial distance $r_i$.

   b. Compute the hydraulic conductivity for this aquifer.