HWRS 582 – Groundwater modeling

HM7 – Transient

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1. The gradient is not uniform for the initial steady state conditions - discuss the influences of recharge and the unconfined condition on this nonlinearity.

As we talked about in the previous report, the recharge and unconfined conditions have a nonlinear behavior. Recharge creates an unbalance accumulation of water (unconfined) or accumulation of energy (confined) because cells in the center of the domain receive more water than the boundary. Near cells collaborate with a flow that already has an extra input from recharge, which means that the flow of one cell is the result of its recharge and the near recharges, which creates a nonlinear behavior. In the case of the unconfined aquifer with constant reference bottom, the transmissivity of the aquifer changes for each cell because this depends on the saturated thickness. However, the saturated thickness depends on the result of the water balance of the cell which depends on the transmissivity. Therefore, all the system is coupled. As results, the steady-state condition is not linear (Figure 1)

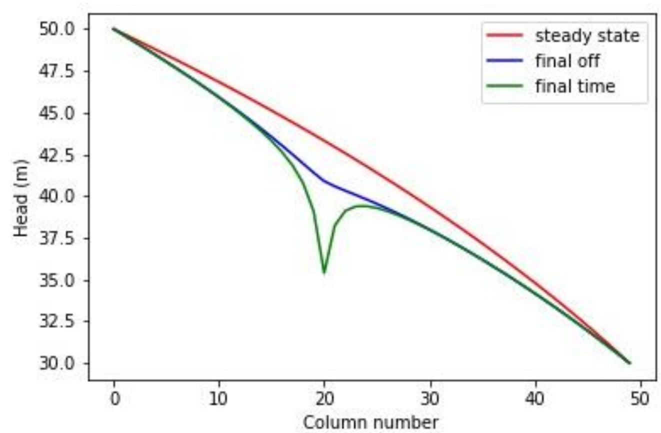

Figure 1. Cross-section through the well.

2. Determine if the system has reached steady state - consider a point at the well and another at the center of the domain.

Figure 2 shows how the system reached a cyclical steady state. That can be checked by viewing the horizontal line of the moving average at the end of the period. Moreover, the time needed to reach a steady state is approximately 60 years.

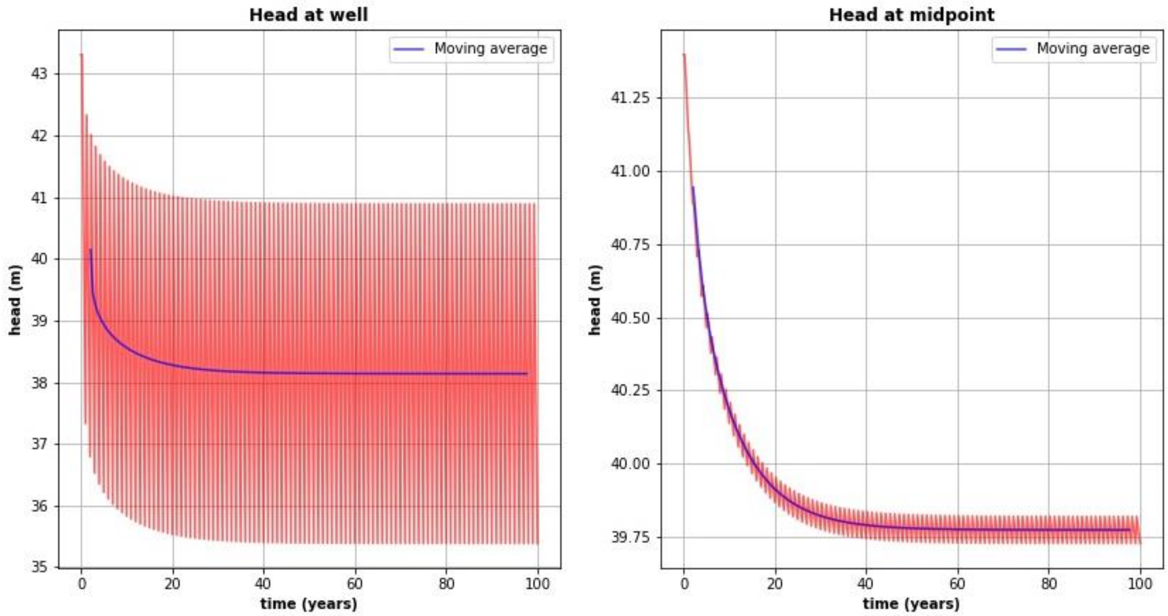

Figure 2. Cyclical steady state.

3. Find the zone of influence of the well defined in two ways: - Based on the drawdown from the initial steady state to the end of simulation time (end of final no-pumping stress period). - Based on the drawdown from the end of the last pump-on stress period to the end of simulation time.

Given the transient behavior in the system, the zone of influence is changing on time too. In the beginning, almost the entire domain is affected by the well because it needs to reach the new steady state (Comparison between the beginning and the end). However, when the new steady state is adopted by the domain, the zone of influence is concentrated near the well. (Figure 3 and 4).

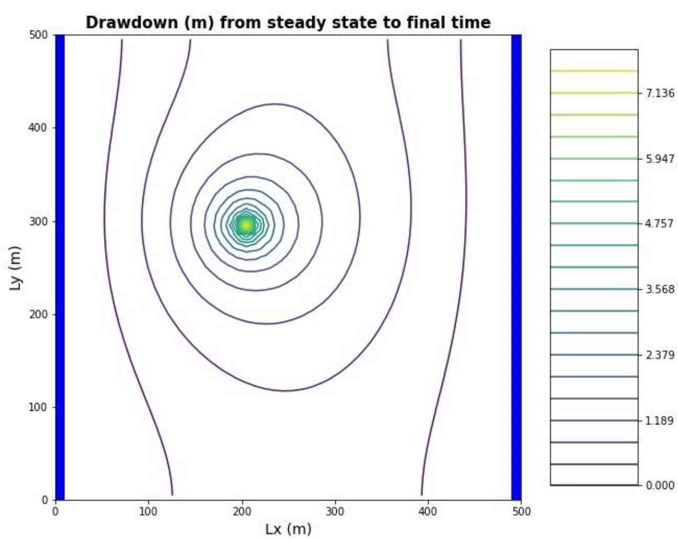

Figure 3. Zone of influence between initial and final condition.

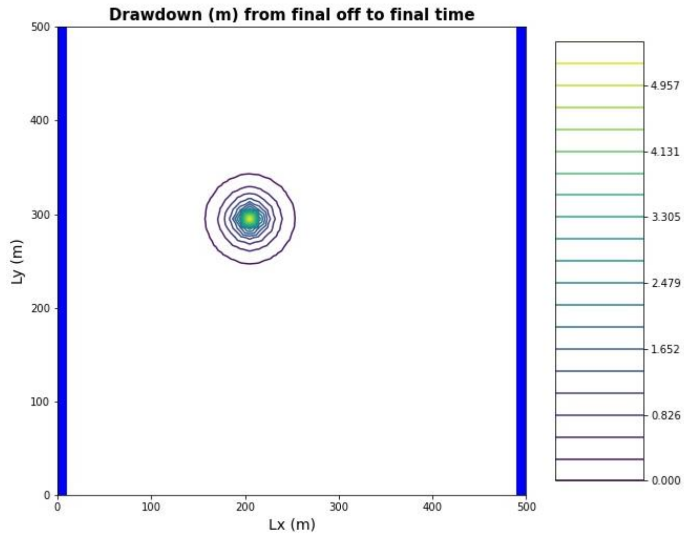

Figure 4. Zone of influence between final pumping and final condition.

4. How long does it take a point at the center of the domain to reach steady state. At that point, explain how you could divide the domain into a steady and transient part and solve each separately.

Using figure 2, we know that the system needs approximately 60 years to reach a steady state. After this period, everything outside of the external circle in figure 4 is in a steady-state and everything inside is in a constant transient. In other words, slight changes inside of the influence zone could be studied with a small domain with a constant boundary condition defined by the water table at the circle.

5. Find a constant pumping rate (same throughout the year) that matches the head time series at the middle of the domain.

The equivalent steady state model considered 251m3/day to have the same behavior than the moving average at the end of the period. However, that does not mean that in the transient process the behavior is the same. Figure 5 shows that the cyclical pumping generates a faster drawdown. That probably because the pumping rate in the cyclical stress doubles the steady state pumping, which forces more the system.

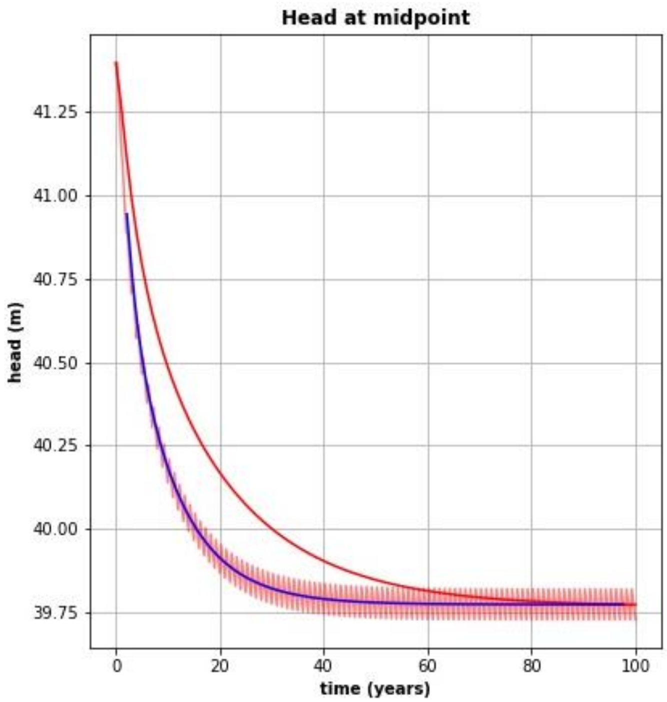

Figure 5. Comparison between cyclical steady state and real steady state at midpoint.

6. Find a constant pumping rate (same throughout the year) that matches the head time series at the well, leaving only a regular, repeating seasonal residual. Are the two pumping rates the same?

In this case the flow was 255 m3/day, which is slightly higher than the previous case. Probably, both values should be the same in the long term, however, give that the steady state is reached asymptoticly there are small differences after 100 years.

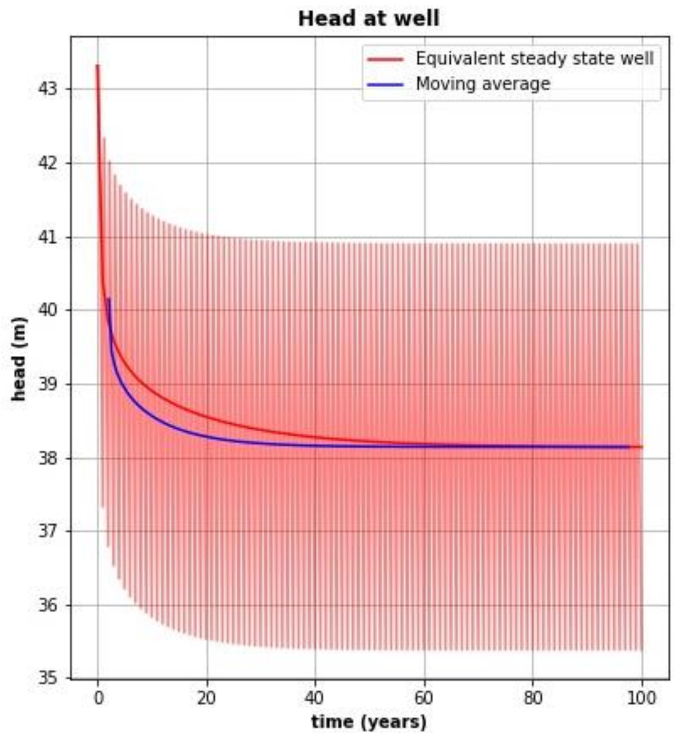

Figure 5. Comparison between cyclical steady state and real steady state at the well.

7. Discuss the sources of water captured by this well. If you're up for a challenge, calculate them for the final pump-on period!

From previous discussions, we know that the source of the water is the boundary conditions (left: Increases the flow, right: decreases the flow) and lower evapotranspiration from the vegetation (not presented in that exercise). However, at the end of the period, given that the zone of influence is surrounded by a steady state, the source of water is just the water coming from the left side that fills the hole (depletion cone) left in the water table.

8. Discuss how you would define the capture zone of the well. How is it different than our definitions of capture zone so far in the course?

In that case, the situation is slightly different. When we turn off the well in the steady-state condition, the flow from the left side feeds the depletion cone but when it is full the well begins again the pumping, so the capture zone is changing on time inside of the cyclical zone, but all that water is pumped for the well but with different timing. Outside of the cyclical zone, the system does not know of the cyclical condition so that flows constantly toward the well. Therefore, outside the capture zone is just the area defined by the vector map, and it is the same at the end of the simulation and at the end of the pumping. (Figure 6)

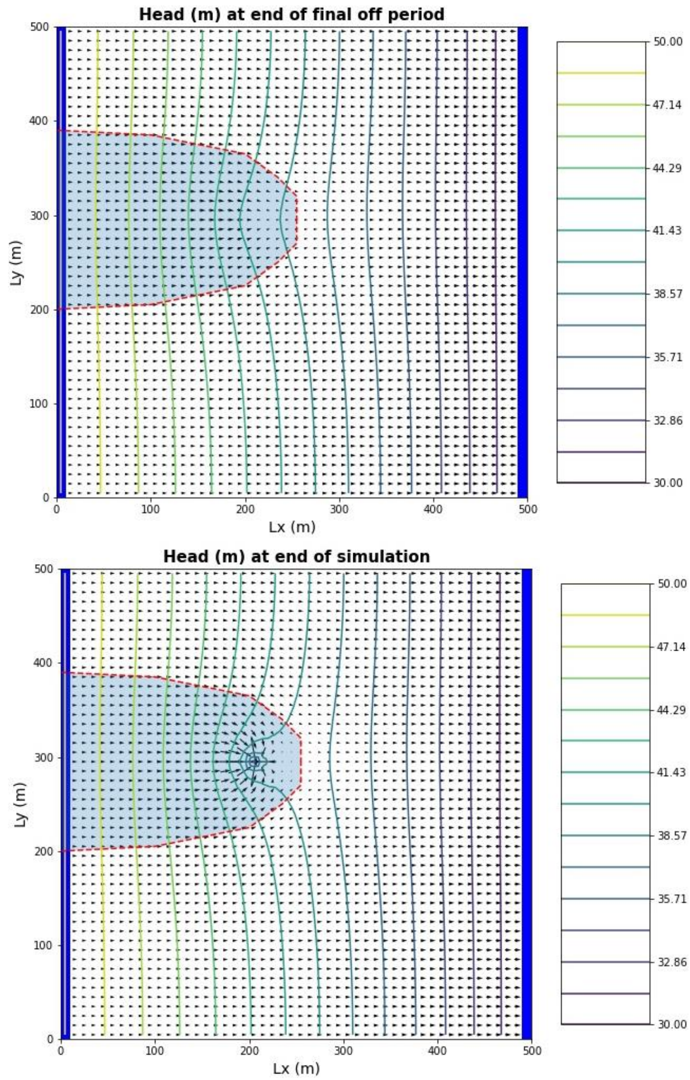

Figure 6. Capture zone of the well at the end of different stress periods.