HWRS 582 – Groundwater modeling

HM6 – Transpired

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1. **For the initial boundary head values and recharge and ET rates, establish the flow across the boundary versus y-distance along the left (15 m) and right (5 m) boundaries. Plot the equipotentials and flow vectors in plan view and outline (hand draw) the area that would be affected by recharge (i.e. if it were contaminated). Also show a contour plot of the steady state ET flux in plan view.**

The flow through the left boundary (Figure 1) has a strange valley on one side. This valley is produced for the recharge from the farm because it is originally pushing in all the direction. However, the background flow has a direction left-right which crushes with the flow coming from the farm. That produces a diminution in the flow in front of the farm. The right boundary has a smoother change across the boundary showing that the effect of the farm is low at that location. Moreover, we can see how the right side has less flow than the left. That deficit of flow is evapotranspirated from the aquifer. Figure 2 confirms the effect of the farm in both boundaries (left: Smaller vectors. Right: Almost vertical equipotential).

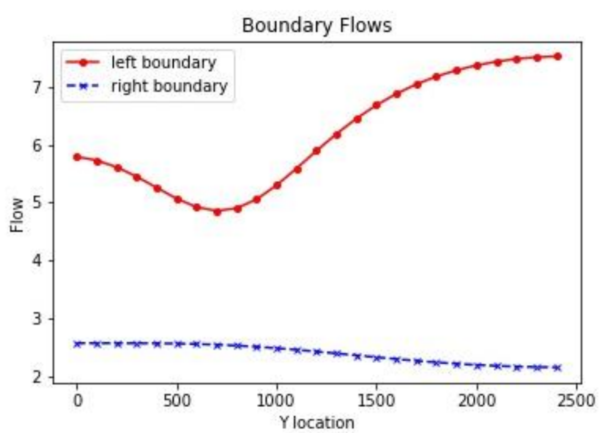

Figure 1. Flow-through the boundaries.

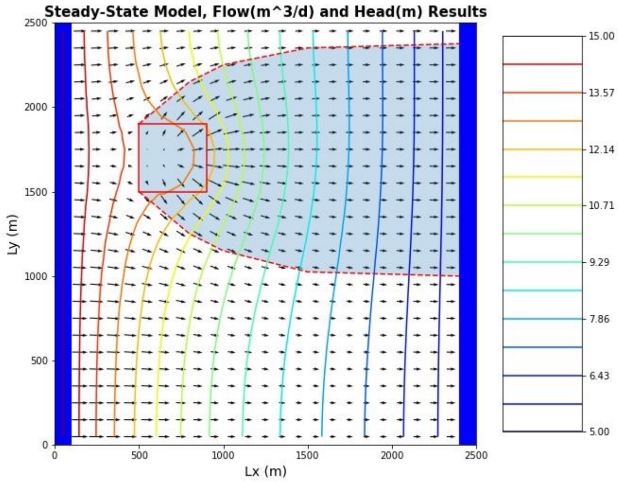

Figure 2. The area was eventually contaminated by the farm.

2. Change the extinction depth. What impacts does this have?.

Given that the ET is modeled as 5e-5 at the top and zero at the extinction depth, any location with a water head higher than 10 will have the same ET (red area). The transition is the region affected by the extinction depth. That means that higher extinction depths (deeper roots) have higher regions affected by the linear ET.

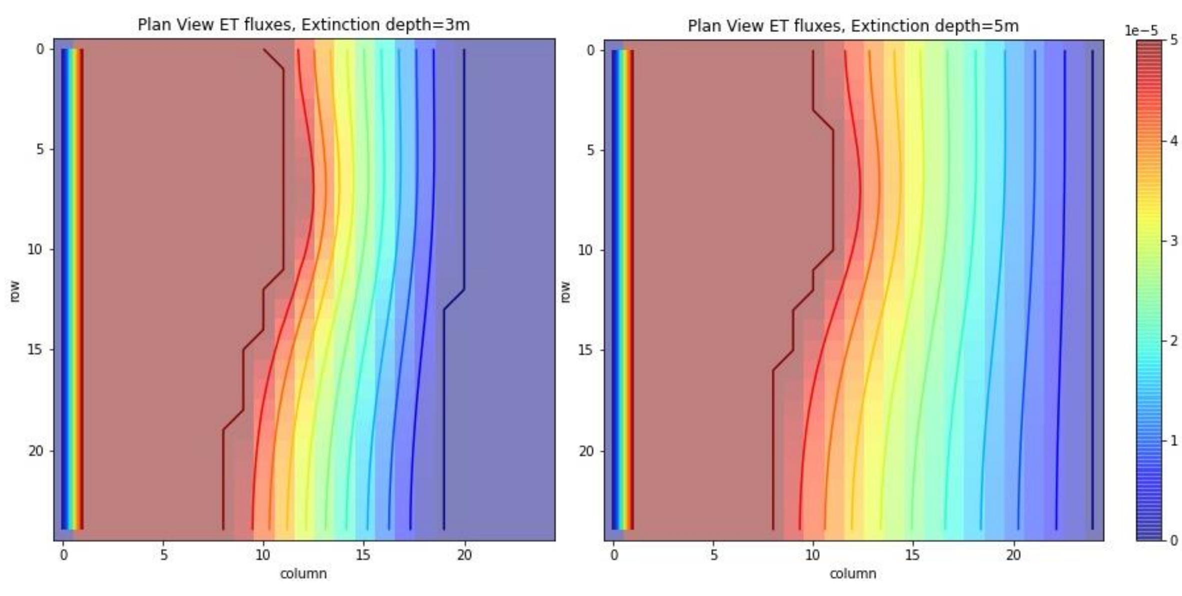

Figure 3. ET fluxes for different extinction depths.

3. Explain, conceptually, how MODFLOW is representing ET. How does this compare to your intuitive understanding of ET in the real world?.

As explained before MODFLOW assume a linear transition of the ET with the depth. If the surface is saturated, then the ET is the maximum and the value decreases with the dept until the extinction depth where ET is zero. If the water table is lower than the extinction depth, there is not ET. When the ET is between the top and the extinction depth, the cell has an interpolation between the maximum ET and zero. That implementation is a very simplified representation of ET because it depends on the kind of vegetation, root density, etc. Each plant has its root structure depending on the water availability which probably follows a Gaussian distribution.

4. Now start the well pumping, extracting 20 m3/day. How does the well change the zone that is affected by the recharge area? How does it affect the ET map? Write a mass balance for the well - how much water is coming from a boundary? How much is originating as recharge? How do you account for the impact of ET on this mass balance? At steady state, what are the effects of 'capture' by the well?.

The well generates a preferential flow between the farm and the extraction, which modifies the equipotential especially close to the well (Figure 4). Given that the well is located where the ET is very sensitive to the water table (linear transition) the ET map had a big change. The area where the ET is zero increased what means some vegetation is losing the source of water (Figure 5). In fact, figure 6 shows that the difference in the ET in the situation without and with well create a big affectation region that extends in all the y-direction. That change was quantified as 9 m3/day of less ET, which represents 45% of the flow pumped by the well.

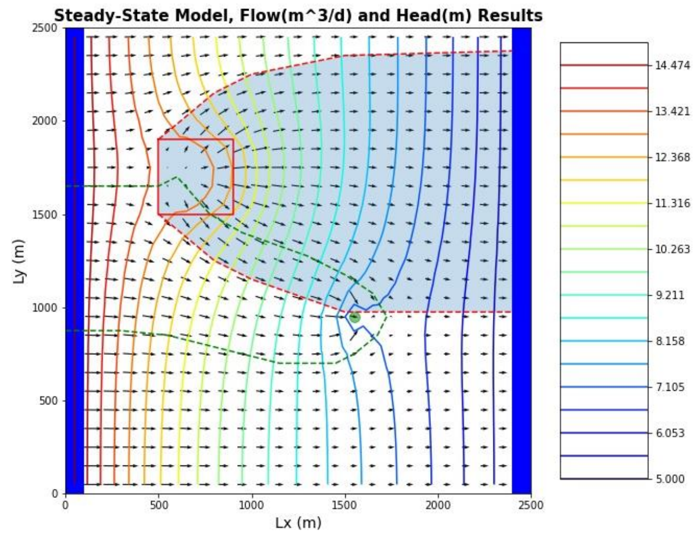

Figure 4. Equipotential and vector in the situation with well.

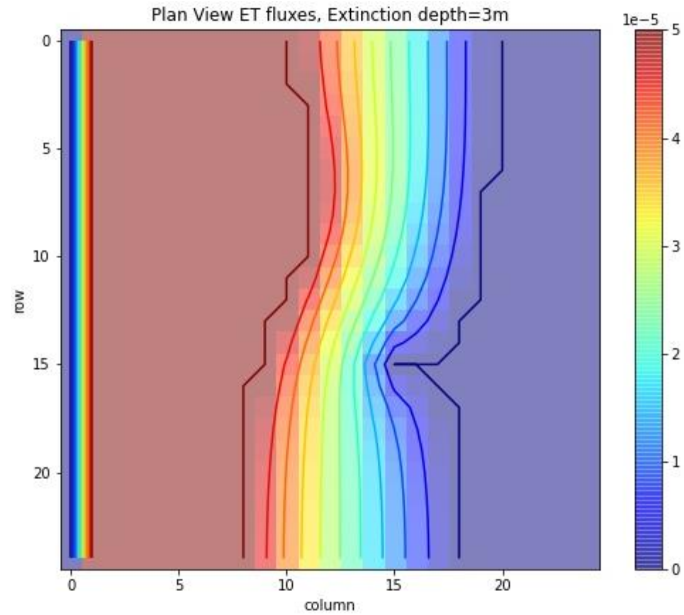

Figure 5. ET flux in the situation with the well.

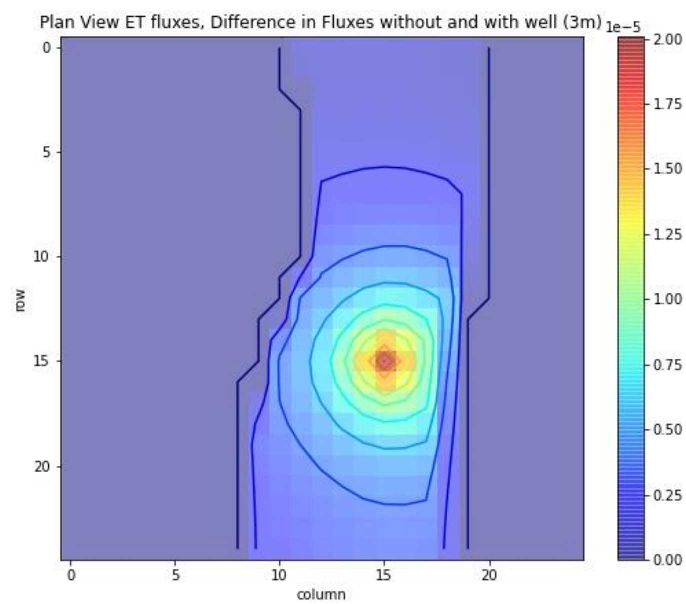

Figure 6. Change in the ET flux in the situation with and without well.

The water balance is telling us the direct source of the water pumped for the well through the capture zone which is different from the affectation zone presented previously. To do the balance we have to quantify all the input (left boundary and farm) and outputs (ET and pumping).

Inputs:

- Left boundary: 45.6 m3/day (doing the sum of the flow between position 7 and 15 of the array)
- Farm: 3.5x5e-4x100x100=17.5 m3/day (flux x area)

Output:

- Well: 20 m3/day
- ET: (3x25x5e-5 + 1x25x2.5e-5)x100x100 = (0.00375+0.000625) x100x100 = 43.75 m3/day

Balance

- 45.6 + 17.5 = 63.1 ~ 63.75 = 20 + 43.47 m3/day
- The difference is due to the approximation in the each of the quantifications.

Finally, if we want to know exactly how much water comes from the farm we have to the water balance in the intersection area of the capture zone of the well and the affected region by the farm.