HWRS 582 – Groundwater modeling

HM9 – River

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1. Use these figures to describe the nature (direction/magnitude) of stream/aquifer exchange along the stream. In particular, explain why the leakage changes magnitude or direction where these values change.

Given that the model begins with zero flow in the stream, the red line (Figure 1, left chart) begins at this point and progressively it increases which means the stream is gaining water. The vertical difference between the blue and the red line is the amount of water gained. The abrupt changes in the row 20 and 26 are due to the change in the conductance of the riverbed. In row 29 the stream change from gaining to losing water, which means that the water table close to the river is lower than the river. In row 45 the river lost all the water, and the water table begins to change toward a situation where the level is mainly controlled by the boundary conditions, which is represented with an abrupt change in the water table. In other words, the water table without the river would be 20 cm lower than the imposed by the river in row 45. The same reason can explain why the rate of losing water increases between row 29 and 45, even though the difference between the head in the river and the cell is almost the same, the decrease in the right boundary condition requires more water which is delivered by the river without a change in the head (like a type I boundary condition)

In figure 1 right chart, we can see that the water table is higher than the head in the river in the first 29 rows. Then the water table in the cells where the river is, has a constant head only thanks to the supply of water from the river. After the water is over, the water table decrease abruptly to the condition without river or where the drivers of the system are only the boundary conditions.

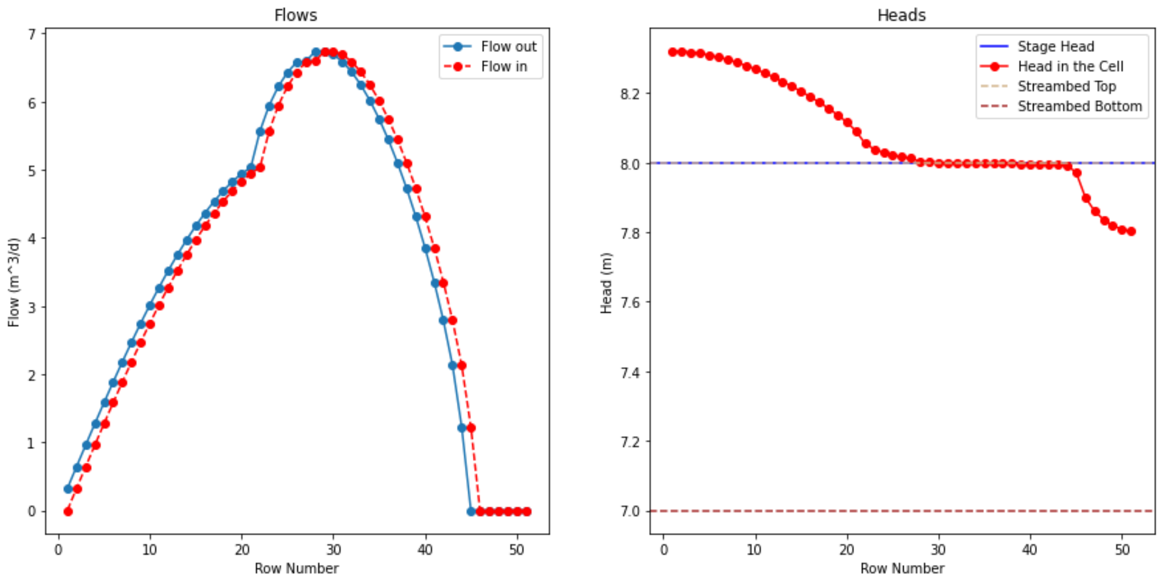

Figure 1. Flow and head distribution in the river.

2. Use the head distribution to describe the movement of water across the boundaries and into/out of the stream.

Figure 2 shows that in the left boundary the flow is low and almost constant, probably because almost all the water is supplied by the top of the right boundary condition and redistributed by the stream. Given that the boundary condition in the right defines only the energy, that allows the system to import or export water from outside of the domain. That situation is clear when we watch the directions of the arrow in that boundary.

The domain has two regions completely different on both sides of the river. That shows us that rivers could be used as boundary conditions if we know the head at each location. The left side represents a system where the movement is almost constant in space. The right side has a high flow from the boundary which changes direction to leave the system at the bottom. The river does not have a high effect in the upper haft of the domain, but after that, it supplies the water required to keep a constant head. At the bottom of the domain, we can watch how the left side of the domain support water when the river is dry.

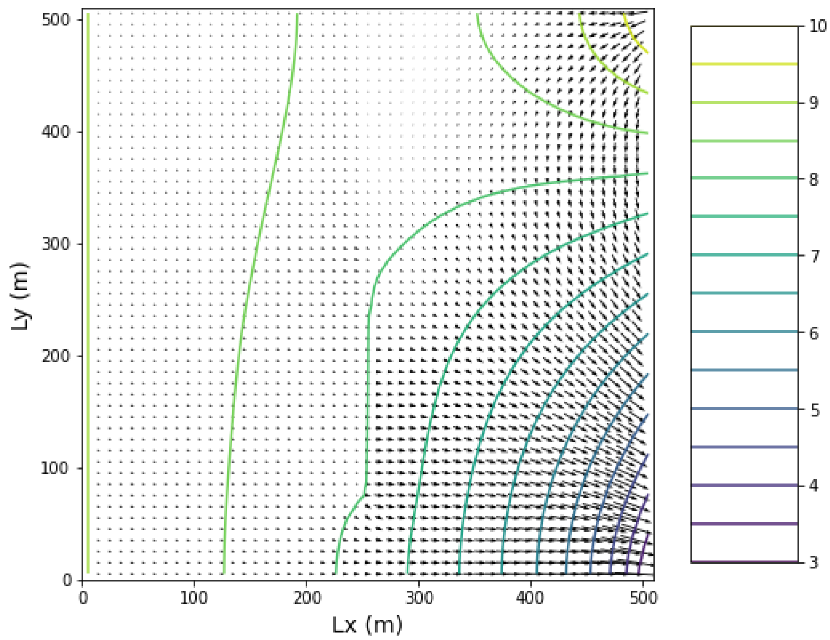

Figure 2. Equipotential for the baseline model.

3. Choose two things to explore.

a) The stream always has a slope, and this affects the results.

In the previous model, the streambed was represented as horizontal even though it had a slope of 0.0001 m/m. Figure 3 shows the comparison between the flat representation and the stream with a decrease in the streambed elevation. In other words, the riverbed has a different elevation for each cell, which is the result of the decreasing calculated as slope and the distance from row 1. Given that the magnitude of how much water is gaining the stream depends on the gradient between the water table and the water level in the river when the stream is deeper it can gain more water (row 30) than the flat representation. In the other case, when the river is losing water, the magnitude of that depends on how deep the water table is which is controlled by the boundary condition. Therefore if the stream is deeper than the flat representation it will lose less water (less difference between water in the river and the right boundary condition). In summary, the change in the representation allows the stream to extend more than 7 rows the water in it.

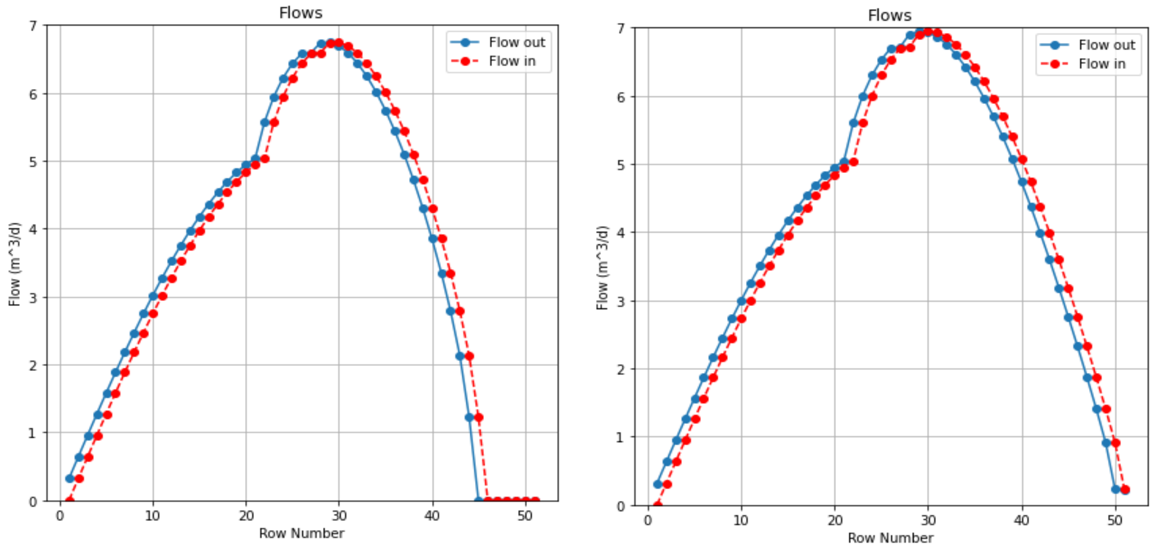

Figure 3. Comparison in flow between flat stream (left) and with slope representation (right).

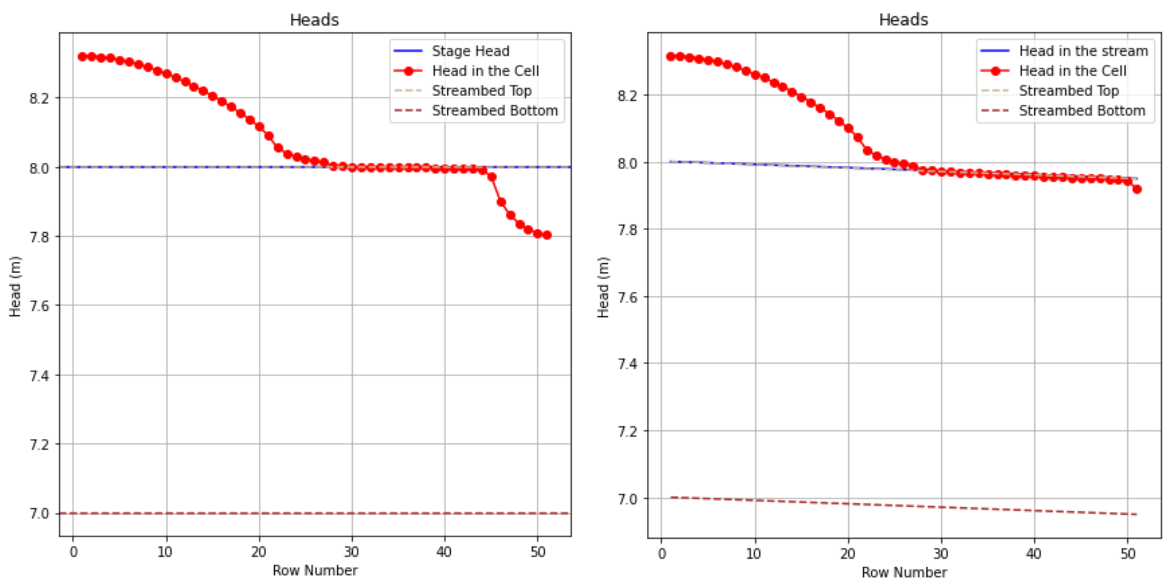

Figure 4. Comparison in Heads between flat stream (left) and with slope representation (right).

b) Is the soil between the streambed and the water table always saturated?

To test that question I fixed the boundary conditions (left and right) in 2m, and I deleted the recharge. This way we can watch just the effect of the river in the domain. After that, I tested different values of conductance in the riverbed to compare the change in the shape of the water table under the river.

The logical answer to the question is “yes”, however it depends on the conductance of the streambed. We can think of two extreme cases, the first is a streambed with gravel in the entire domain, which means that a lot of water is going from the river to the groundwater and we are sure that all the soil under the river is saturated. The opposite case should be clay in all the domains, therefore the flow would be very low. In this case, we can ask if the amount of water living the river is enough to saturate the soil. When I changed the hydraulic conductivity in the streambed from 1 to 0.01, I found that the water table does not reach the river, which would mean that the water when it leaves the stream is moving in the unsaturated region which is not represented by modflow. That creates a water table disconnected from the river for low conductivities. However, if we would have the chance to model the saturated and unsaturated regions, certainly we will see the wet area in the unsaturated region.

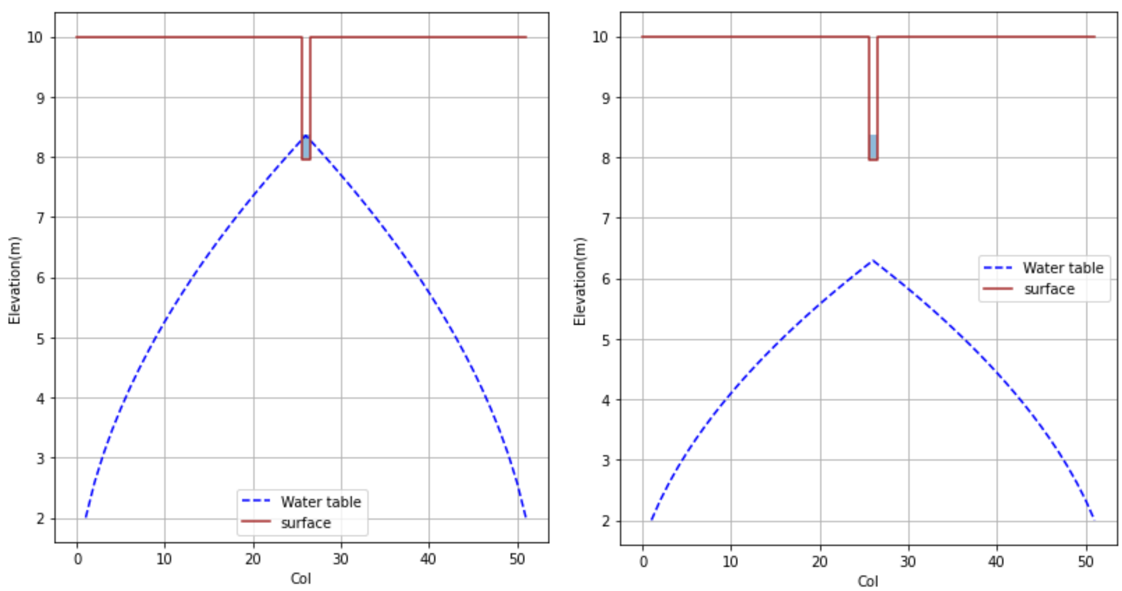

Figure 5. Comparison in water table between K streambed=1m/d (left) and K streambed=0.01m/d (right).