Aquaseca: Scenarios 5 and 6

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Exercise

Build a model representative of the Aquaseca basin to analyze the effects of the proposed GroMore development. The following scenarios were run to compare post development effects on the basin's hydrology. All scenarios were run with the proposed agricultural development.

1. Add the proposed agricultural element (pumping and localized recharge) for growing pistachios to your post-development model with seasonality. Agriculture starts now, 100 years after the end of the burn-in. Both pumping and recharge related to agriculture occur at the rates described and are continuous throughout the year.
2. Moving forward, we will be running more models to try to decide whether to allow the agricultural activity and/or whether to propose changes to its design. Whenever you are faced with running many models (or calibrating a model), it is worth considering carefully whether the model can be simplified. But we want to make sure that we don't misrepresent any important impacts of the farm. Consider the question of ignoring seasonality from the point of view of four stakeholders: the agricultural company proposing the new facility, the town, a local environmental group, and the Environmental Protection Agency.

Questions:

1. How can you quantify the impacts of the proposed agricultural element on the hydrologic system 100 years into the future? How do these impacts compare with the impacts of the town's pumping? How will the agricultural element affect the town's ability to meet its water demand (both for quantity and quality?) Describe your metrics as precisely as you can and quantify the impact(s).
2. Can we justify ignoring seasonality in ET? If so, we could use a constant rate which would make our model less dynamic and probably faster-running. Provide a one paragraph supportive of your position.

Solution

Model setup:

Refer to the ipython notebook to view all the steps in the model setup. The main modification made to these scenarios was the addition of the proposed agricultural development.

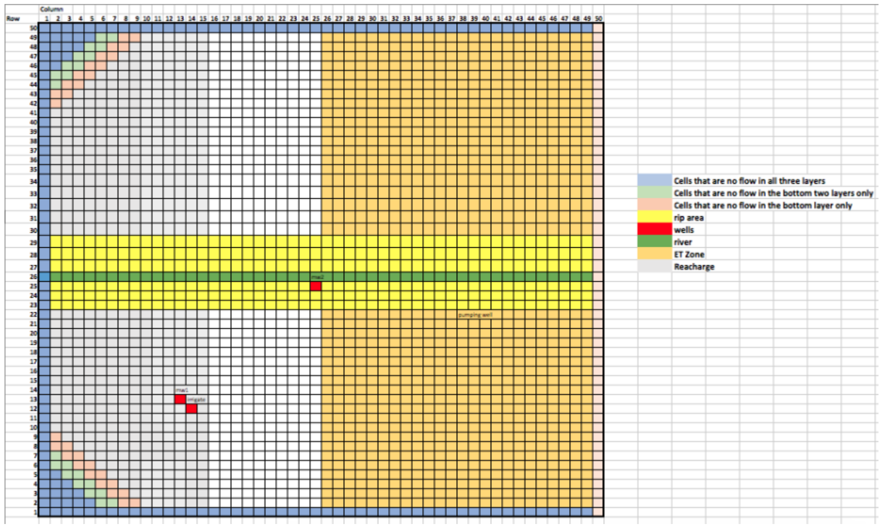


Figure 1: Domain setup

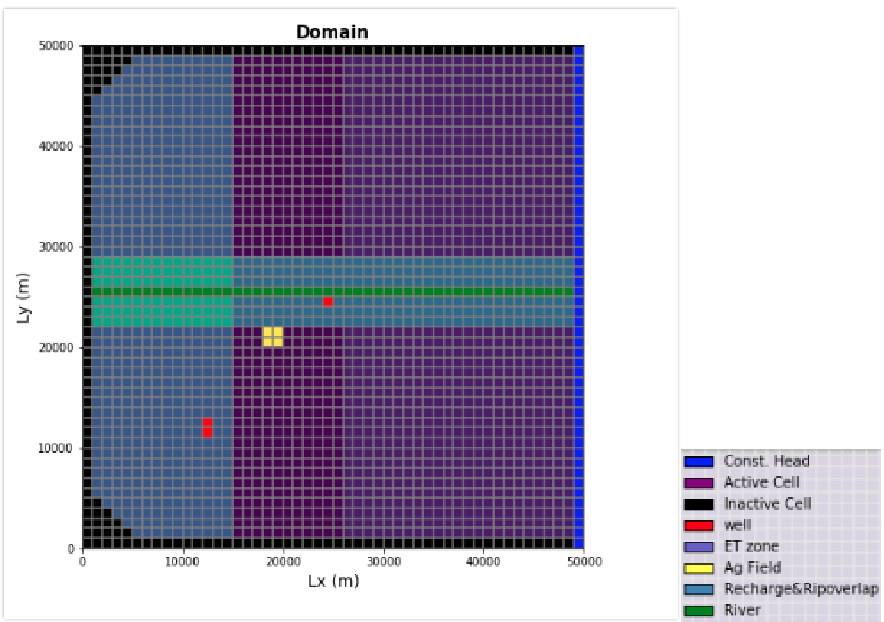
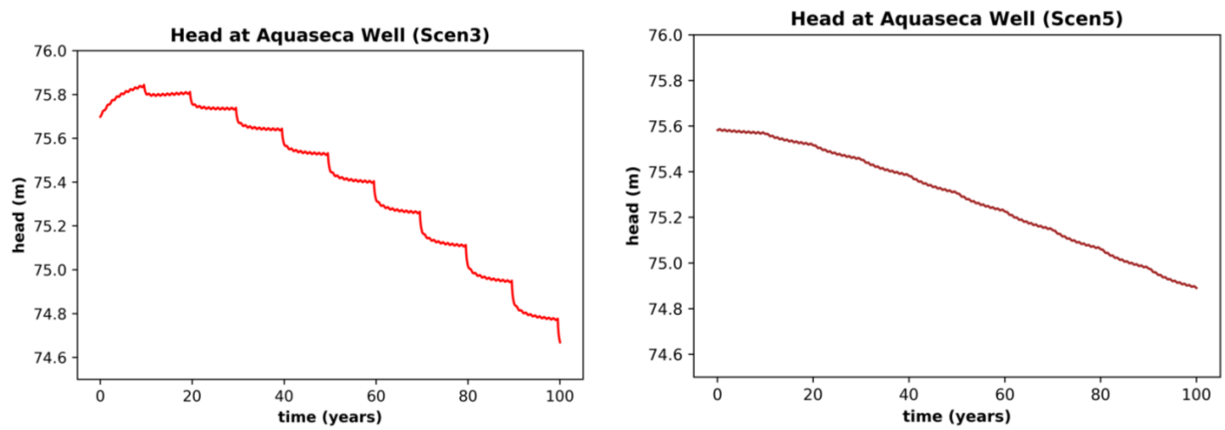


Figure 2: Model Map View of Domain

Results:

1. We first looked at the head changes at the town and irrigation wells. Surprisingly, the head drop at the town well was the same with and without the irrigation well pumping (Figure 3a-b). Figure 3a does show a slight increase in head before it begins the negative trend; however, this head change is negligible (20cm). The scenario 5 hydrograph for the Town's pumping well is shallower and shows slightly less head drop over time. This could be the result of the upgradient recharge from the ag field mediating the fluxes. Because of pumping at the irrigation well, the head profile looked radically different for the two scenarios Figure 4a-b). The decrease in head

due to pumping for 100 years is only 3.5m, which is a fairly small impact on the hydrologic system for that amount of time. That value is also greater than the 0.8m change in the supply well.



Figures 3a-b. a. Head profile at the Aquaseca supply well for 100 years of town well pumping. b. Head profile at the Aquaseca supply well for 100 years of town and irrigation well pumping.

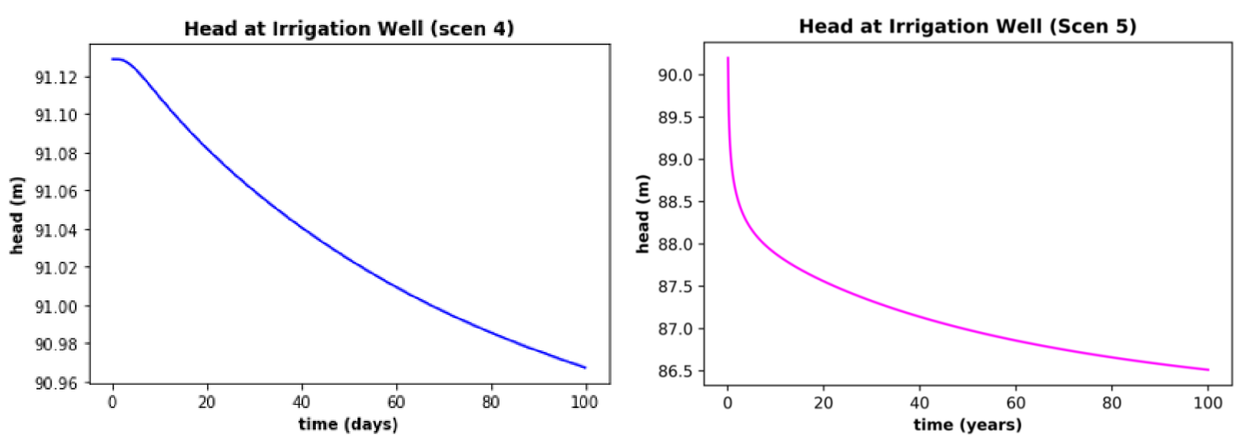


Figure 4a-b. a. Head profile at the irrigation well for 100 years of town well pumping. b. Head profile at the irrigation well for 100 years of town and irrigation well pumping.

Next, we compared various values from the water budget to quantify the impact of the proposed agriculture development (Table 1). Table 1 displays the annual water budget for the final year of each scenario. The "current" status of the system is what the water budget looks like after 100 years of pumping from the town well. It is clear from Table 1 that the pumping rate has a greater magnitude than the other inputs and outputs to the stream. It is clear from Table 1 that the pumping rate has an impact on the other inputs and outputs to the system. For example, the addition of irrigation well changed the water budget of the system for every variable. The pumping budget doubles between Scenarios 4 and 5 because of the additional pumping. Besides the pumping differences, other changes in water budget features between the end of scenario 4 and scenario 5 indicate the impact over the next 100 years from adding the ag field and associated pumping. First the largest difference is the stream leakage, scenario 5's stream leakage is 62% greater than scenario Note that the ET does not increase , as one would presume with the watering of crops because it was accounted for in the recharge of the pistachios. ET actually decreases slightly; this is likely caused by the water table lowering closer to the ET extinction depth. This shows a slight indication that the pumping is stressing the decrease in groundwater outflow stems from the fact that more water is being pumped and this results in a decrease in outflow as some of that water enters the pumping wells.

Table 1. Different components from the annual water budget are displayed for Scenarios 3, 4 and 5 in ac-ft/year and m3/yr.

Annual Water Budget						
	Current (Scen 3)		100-year No Ag (Scen 4)		100-year Ag (Scen 5)	
	Acre-feet/year	m^3 / yr	Acre-feet/yr	m^3/yr	Acre-feet/yr	m^3/yr
Pumping	433.78	535057.38	1226.91	1513370.81	2540.27	3133370.81
ET	82.08	101249.28	82.08	101249.28	81.00	99907.29
GW Outflow	179.94	221949.76	179.75	221715.40	162.87	200896.99
Recharge	253.72	312960.00	253.72	312960.00	259.56	320160.00
Stream Leakage	58.79	72516.09	59.43	73308.75	96.35	118840.70
Storage Change	-383.29	-472780.33	-1175.59	-1450066.74	-2428.23	-2995174.38

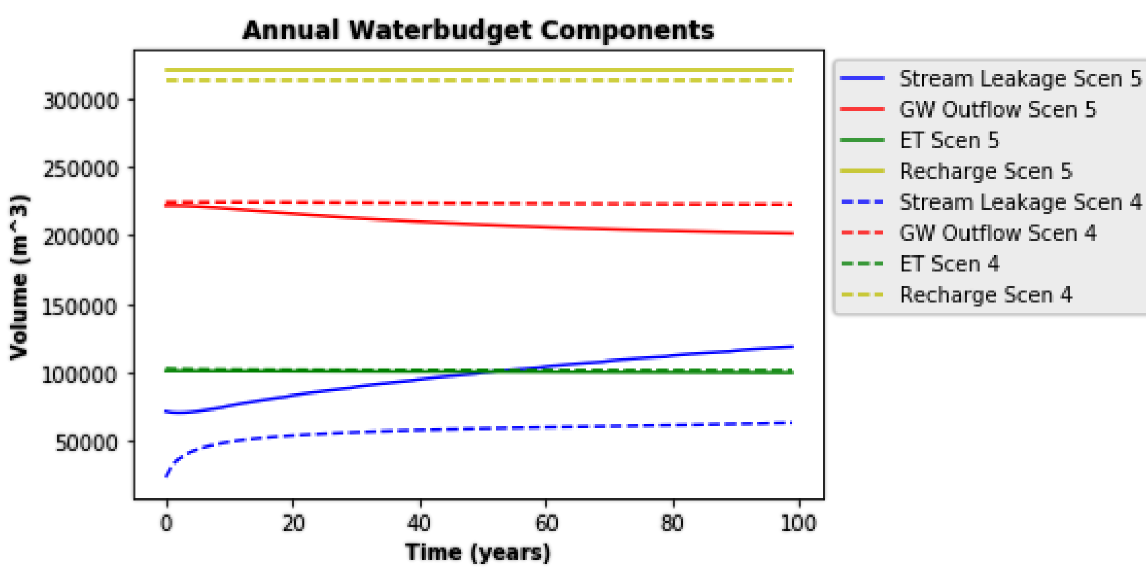


Figure 5. Plot displaying the water budget over time for leakage, ET, groundwater (GW) outflow, and recharge.

In Figure 5, the annual water budget components are plotted across the 100 years for both scenarios 4 and 5. The pumping dwarfed these other elements, so it was not added to the plot but from the description the pumping is obviously far greater in scenario 5. The stream leakage in the beginning of scenario 4 has a greater change than scenario 5, this could possibly be from the ag field recharge offsetting the initial stream leakage. As can be seen in table 1, as pumping increases in scenario 5 more stream leakage is pulled into the system and less groundwater out flows. Groundwater outflow change is negligible in scenario 4.

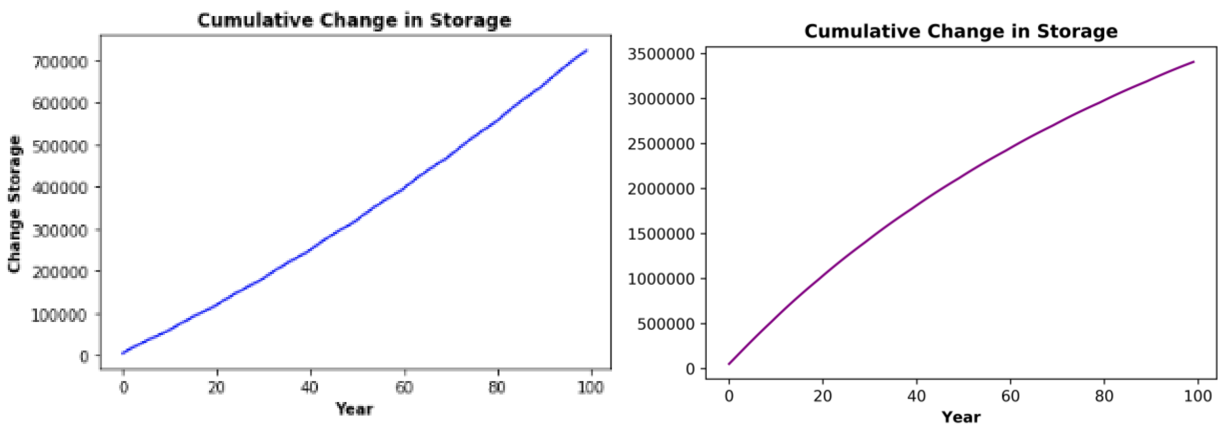


Figure 6a-b. a. Cumulative storage over time for Scenario 4 (100 years). b. Cumulative storage over time for Scenario 5.

We also plotted cumulative storage over time for Scenarios 4 and 5. This time we used the storage calculated by Modflow in the water budget. We obtained different values than those displayed in Table 1, but the trends are the same. We could not reconcile the differences in the two values, it is likely attributed to how the budget headfile reads storage change compared to the calculation of the storage change as 'leftover'. Fortunately, they both acted similar, as the amount of pumping increases, the amount of water drawn from storage also increases (Figure 6a-b).

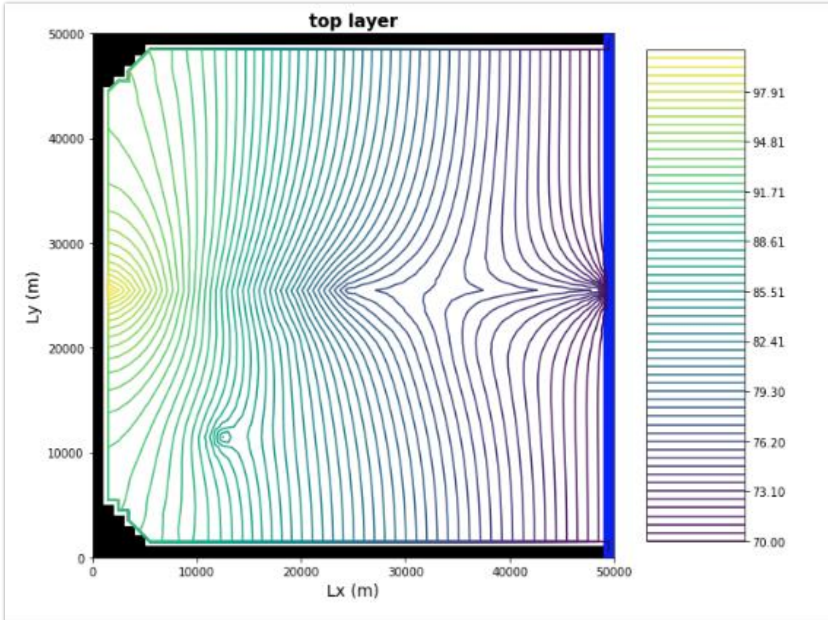


Figure 7. Head contours for the top layer of the domain.

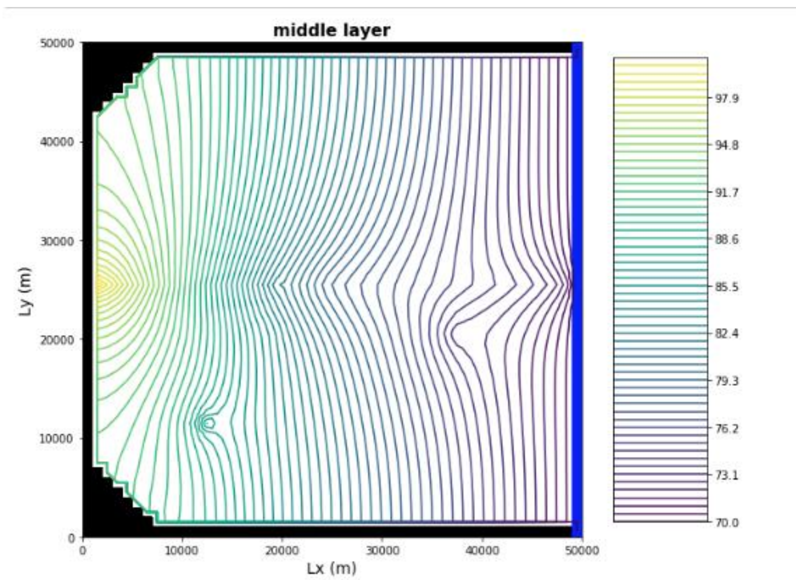


Figure 8. Head contours for the middle layer of the domain.

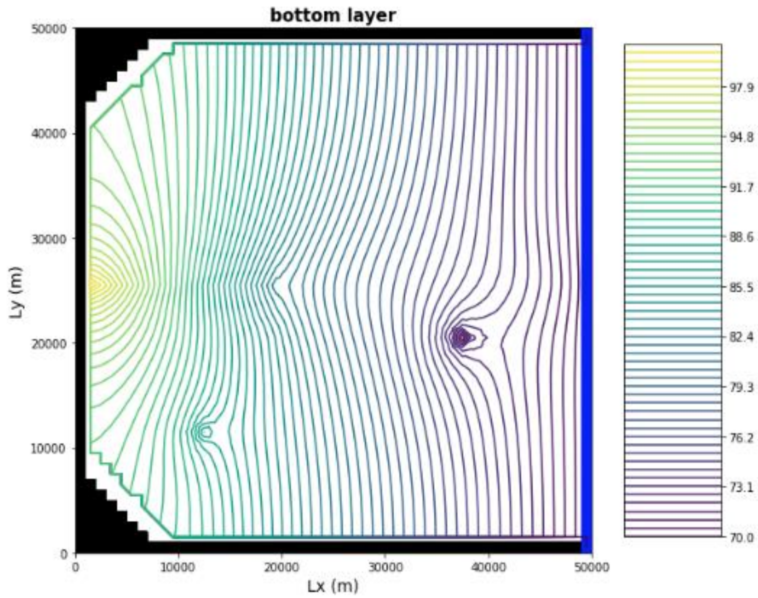


Figure 9. Head contours for the bottom layer of the domain.

2. Based on our analysis, the ET seasonality can be ignored for this hydrologic model. The difference in the affect ET has on the system can be seen in Figures 3a and b. in particular, Figure 3b shows very little seasonal differences in head, which is likely due to the dampening effect that additional pumping had on it. We recommend using a constant ET rate, which could be the average of the two ET values from each season. We are more concerned with the impact of the irrigation well on Aquaseca's water supply than we are with the seasonal variations in water level that are less than 10cm. If the seasonality had a larger effect on the head in the supply well (e.g. magnitude of 1m or greater), we would keep the varying ET.