FINAL_ChallengeAnswers_Portillo.md

Challenge #3: Box Model - Flopy

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For this assignment, we used Flopy to model a homogeneous 'box' with a low k inclusion at the center making the entire model heterogenous.

Explain why the values are not constant along the boundary (relate to the definition of a Type I boundary). Explain why the flow distributions are the same for the left and right boundaries.

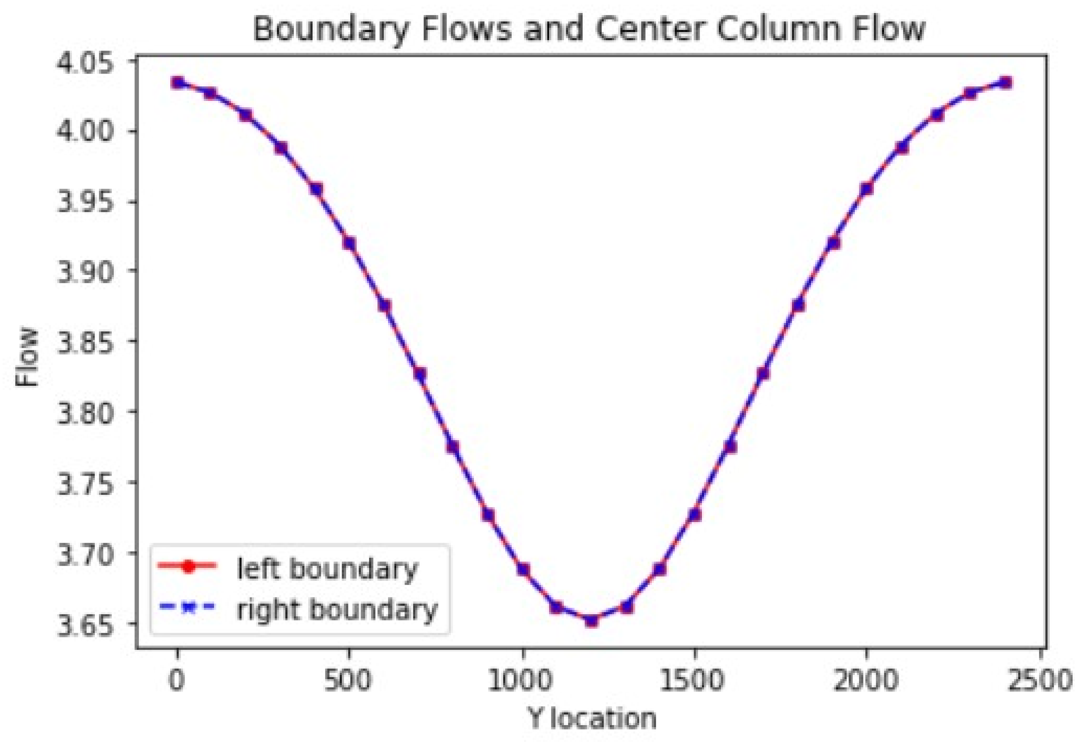


Figure 1 Flow along the left and right boundaries

In a Type I boundary, the head is specified at that boundary. When the K is known within the model, the flux will adjust to meet the boundary conditions and the K distribution. In this case, we see flow at the top and bottom to be the same value because of the symmetry of our model; the same amount of energy has to be lost on either side. In the middle, however, the flow decreases dramatically. This is because the low K inclusion in the center allows for the flow to continue around these zones pushing only a small amount at a lower rate through the center. The local K values at the right boundary adjust to the K inclusion values and the flux responds to this change by decreasing. But what does this look like down the center?

Add a plot of the left-to-right flow along a line that passes through the center of the inclusion. What can you learn from comparing this distribution to that seen on the boundaries?

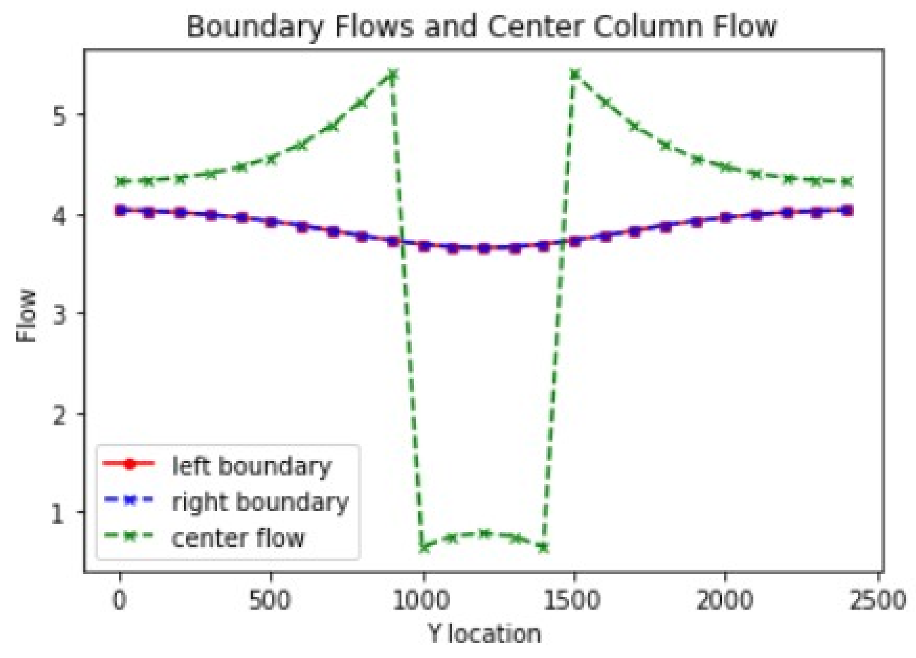


Figure 2 Fluxes at the boundaries and down the center

In figure 2 the flow pattern differs greatly from figure 1. This illustrates how the flow moves around the low permeable zones. Flow increases because the flow path is now longer as flow moves along and around the low K zone and we see a dramaticallylower flux within the zone as flow struggles to find an easier route. This influeces the 'dip' we see in Figure 1 which the flux responds to the low k zones.

Calculate the total flow into (and out of) the domain.

Use this to calculate the Keq of the heterogeneous system with the K values as given in the starter code. Repeat this calculation for the following K values for the inclusion (keeping the background K as it is given): 0.01, 0.1, 1, 10, 100.

qin = qout

The estimated total flow is approximately 104 cubic meters/d (when averaged between all changes of K inclusion). The following are the calculated values for Keq for each K inclusion:

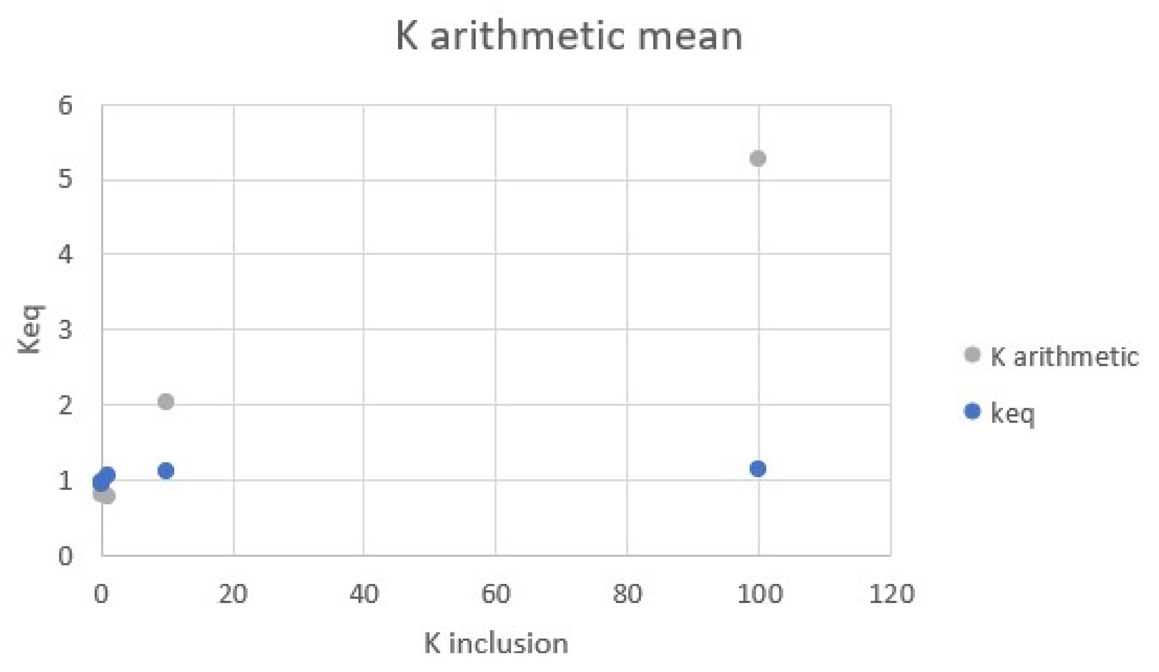
K inclusion (m/d)	Keq (est. m/d)
0.01	0.948
0.1	0.966
1	1.041
10	1.116
100	1.133

Can you draw any general conclusions about the impact of high or low K heterogeneities on the equivalent K for the flow system examined?

Does the equipotential distribution depend on the absolute or relative K values for the background and the inclusion (e.g. K_background = 1 and K_inclusion = 0.1 vs K_background = 10 and K_inclusion = 1?)?

On orders of 10, there isn't a ton of change for Keq. This suggests that media with heterogeneity of three orders of magnitude difference will likley shift the Keq of the system than a difference of one order of magnitude. This could also mean that Keq will liklely ignore small, subtle differences in magnitudes of the hydraulic conductivies. Below, figures 3 and 4 display the comparision between Keq of the system, and both the harmonic and arithmetic means for each change. The harmonic mean values are more representative of layers in series whereas arithmetic mean values are more likley to be precise with parallel layers. In Figure 3, we see a larger variation and not highly correlated arithmetic mean with Keq, suggesting this model doesn't have parallel layers. We also see this in Figure 4 because the harmonic mean isn't taking into account the low K zone as it tries to simplfy the model into zones in series.

I think the equipotential contours depends on the relative K rather than absolute. We see this by comparing the head distributions for each change of K inclusion. The contours don't chage dramaticall because the system is spending less energy through the low K inclusion as the flux isn't 'forcibly' directed into it.



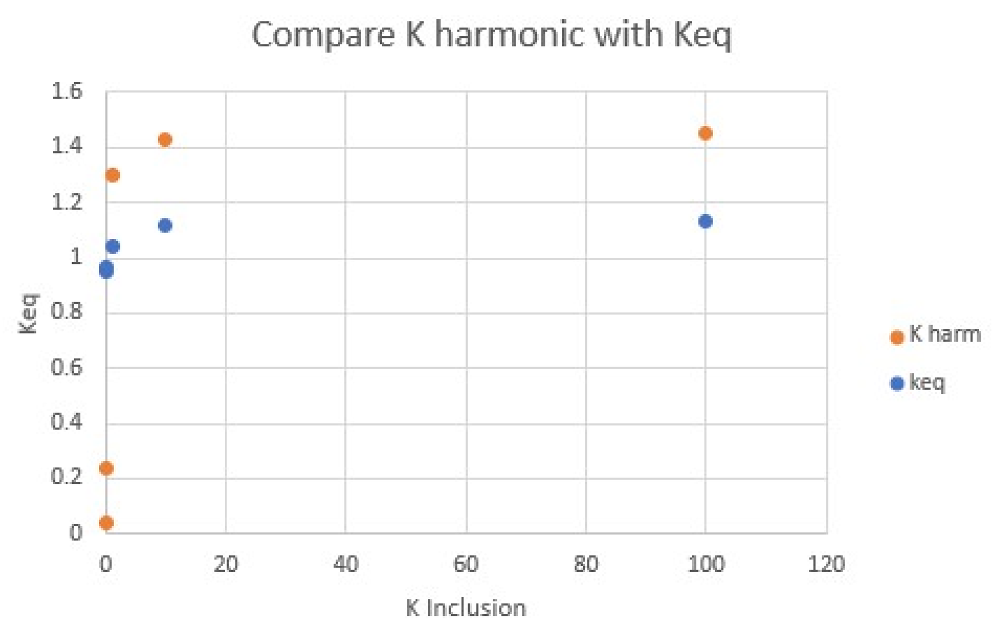


Figure 3(top) Comparison between Keq and K arithmetic

Figure 4 (bottom)Comparison between Keq and K harmonic mean