**Homework 4 Discussion**

**Discussion Questions:**

1. *For the initial well location, plot the total flow into the left (constant head = 20) and out of the right (constant head = 10) boundaries. (The code, as provided, makes this plot for you.)*

* *Explain why the values are not constant along the boundary (relate to the definition of a Type I boundary).*

The flux values are not constant along the boundary because they must change in response to the increased head gradient introduced by the well in order to maintain the specified head set at the Type I boundary.

* *Explain the shapes of the flow distributions and why they are not the same for the left (inflow) and right (outflow) boundaries.*

The shape of the flow boundaries reflects the higher and lower fluxes felt at the left and right boundaries respectively due to changes in head gradient along the path to and from the well. The well intercepts flow which drives up flux along the inflow boundary and reduces flux along the outflow boundary.

* *You are still modeling stead state conditions. So, what is supplying water to the well?*

The infinites sources of water we created when we established a Type I boundaries are supplying water to the well.

1. *Plot series of the flow L-R along a vertical line that passes through the center of the well [:,12]*

* *How do you interpret the flow along this transect? (Hint, also look at the flow along a transect just upgradient from the well [:,11]).*

Flow is moving into the well and leaving the domain. It appears to have a steep drop off in flow along the transect that passes through the middle of the well because these flows are being measured at the right face of the cells. When we take a transect passing through the cell just to the left of the well and measure the flow across its right face, we see a large spike in the flow approaching the well as it is satisfying the specified flux set at the well cell.

1. Chart

   Description automatically generated*Then, look at the plot of equipotentials (i.e. the constant head lines, this is the last plot in the example) and flow vectors. Describe how water flows through the domain. To aid in your description, draw a line through all of the flow vectors that terminate in the well. This approximates the capture zone of the well. Use this to refine your description of the flow system, being as specific as possible about where water that ends up being extracted by the well originates on the inflow boundary.*

In the image on the right we can see the flowlines that lead from the boundary to the well. It appears to capture about one fifth of the flow. It’s clear that the well does not require a high enough flux to pull water back upstream; in fact, its effect is not substantial enough to be felt in flowlines around the 1200m and 1700m lines.

1. *Then, look at the plan view drawdown plot.*

* *Why aren't the drawdown contours circles? Either explain why this is correct, or fix the plot.*

The drawdown contours are not circles because the specified heads of the boundaries are the dominant forces in determining flow. Furthermore, the well flux is not high enough to divert a significant amount of water from its left to right flowpath.

* *Why are the drawdown contours not equally spaced?*

The contours are not evenly space because they suggest increasing pressure gradients that arise due to radial flow as the flowlines converge, higher fluxes are needed to drive water.

1. *Move the well to [0,5,5]. Use all plots necessary to describe fully how water is flowing through the domain with the well in this location. Be sure to include the drawdown plot in your discussion - compare this plot to the equipotentials and flow vectors.*

According to the drawdown plan view and the flow transect graphs, we can see that a higher flow shifts upward towards the top end of the graph, a result from the well’s new position. Interestingly, it appears that flow increases along the capture area just enough so that what water is not intercepted, crosses the outflow boundary as a constant value, nearly equal to flows moving across the entire length of the boundary. This can be confirmed as the drawdown plot contour extends well past the well point capturing enough water to maintain this constant level.

**Glossary Questions**

1. *What are equipotentials? How do we create them from MODFLOW Models?*

Equipotentials are lines of equivalent head, delineating spaces experiencing changes in head. They are created by using a modelmap.contour\_array() method on python that pulls the head values from the head array, and after setting the number of equipotentials desired, it plots them within the grid space.

1. *What are flowlines? (BONUS thought experiment: How can you impose a no flow boundary based on symmetry? Give it a shot to explain WHY this works in a couple of sentences.)*

Flowlines are lines drawn to represent the path of a water molecule in steady state flow that orthogonally intersect equipotential lines. A no flow boundary could be imposed using an injection well placed equidistant outside of the boundary, pumping at an equivalent rate.

1. *What are flownets? And how does a flonet vary from a map of equipotentials with flow lines drawn on it?*

Flownets are diagrams that illustrate equivalent volumetric fluxes between flowlines. Their flowlines must adhere to the same rule mentioned above and pass through equipotential lines at 90o angles which results in the possibility of drawing complete circles in each square block.

1. *Define the concept of 'capture' in a way that a non-expert might understand? (e.g. think about our homework problem, if the right boundary represented a stream, what would the impact of the well be on the stream?)*

Capture is amount of water that enters a system but does not pass through. You can quantify “capture” by subtracting the amount of water that leaves a system across its boundaries from the amount of water that enters a system.