Danielle Rehwoldt

GWM21

HW 4 – correct figures

1. Explain why the values are not constant along the boundary (relate to the definition of a 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 left boundary shows a slight increase in flow values in the middle of the plot. This is because the well is pulling water, so flow increases towards the well which is in the middle portion of the boundaries. On the right boundary, the water has been used up by the well and therefore the flow is slightly reduced on the right side of the well after the flow passes through. ----The values are not constant along the boundary because of Darcy's law. This is because as we are increasing our horizontal distance, dl, we see a change in dh (shown in equipotential graphs), Q (shown in flow vs. Y location graphs), and K values. This is why we don't see constant values along the boundary. The left and right boundaries for the flow graphs are not the same as we see a symmetrical pattern surrounding the well.

2. Add a series of the left-to-right flow along a 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].

I see the transect at 12 as reaching the well and decreasing flow drastically as water is being held in a stagnant area then pushed out as flow is going from left to right. This flow is not less than zero, indicating that the flow is left to right and does not come back to the well from the right. Once we reach the point of stagnation, the flow goes all the way through towards the right boundary. If we had flow values that were less than zero, we would see a shift in the flow as it will not all proceed from left to right. Some of the water will flow backwards and not go all the way to the right if reaching the stagnation point. When we look at the upgradient transect, we see a sharp increase in flow as the water is being pulled at an accelerated rate near the well. Acting like traffic, some of the flow is being accelerated around the well with some flow ending up in the well at transect 12. ---- These graphs at different transects show opposite flow values (one being the negative value of the other). For the center transect, we approach the well with slightly decreasing flow values and in the middle of the well, the flow values drop to about 0 for the center boundary. The left boundary of the center transect shows a slight increase in flow while the right shows a slight decrease in flow. This is because as it enters the well, there is a "pull" from the well that increases the flow and as it exits with less momentum, we see a lower flow value. The upgradient transect shows opposite values as right next to the well, we experience a pull that isn't "satisfied" where it can't actually be stuck within the well.

3. Then, look at the plot of equipotentials 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 12 transect, the water flows from left to right with the top and bottom of the "capture zone" being no-flow boundaries that force flow in the center towards the well. If the flow is not within the capture zone that leads the flow towards the stagnation point in moving the flow from the left to the right, we see a slight alteration in flow from the outermost vectors. This is shown in the drawing below. ----So as we move towards the center of the well system, along the center line we see arrows pointing in the same direction with an increase in the magnitude of head values on the left and as soon as we enter the well, we see a sharp decrease in those values. The right side (boundary?) shows growing arrows that are still straight as we exit the well. The upgradient and downgradient transects show the vectors pointing towards the well with an increased head value as we approach the well and then show the same decreasing then increasing patterns as we enter and exit the well.

4. 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.

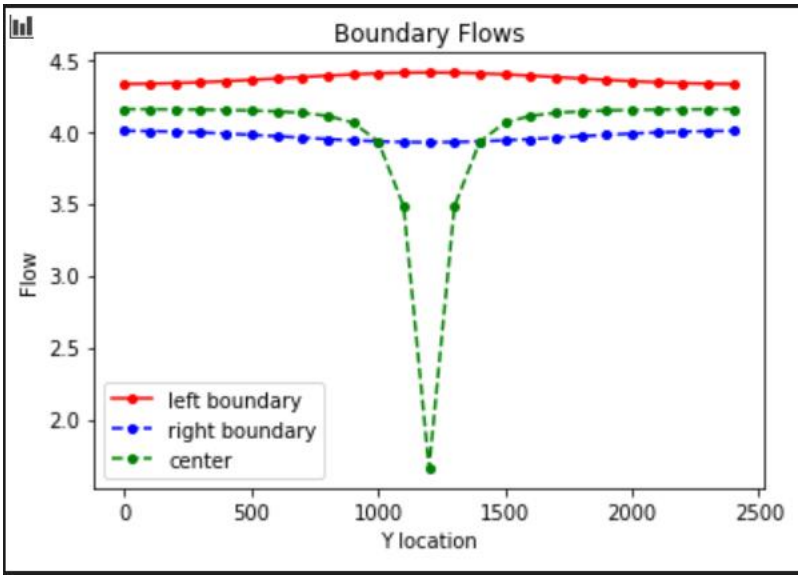
The drawdown contours are not circles because of the a.) scale that is not even which alters the graph slightly and b.) the fact that everything has to flow perpendicularly to the contours. The top and bottom boundaries are Type 2 no-flow boundaries and "squish" the flow forcing the vertical components of flow towards the center. The right and left boundaries are Type 1 constant head boundaries that stretches the flow area horizontally leading the flow in the horizontal component direction. The outer contours are more circular because the drawdown is not enough yet to experience the effects of these boundaries. The inner contours with more drawdown experience these effects and create a more diamond shape as these vertical and horizontal components created by the boundaries begin the enter the well at right angles and therefore making the shape less "continuous". ---The drawdown plot aren't circles because as we enter the well, the change is so sudden that only specific flow values are captured before the values go to zero.

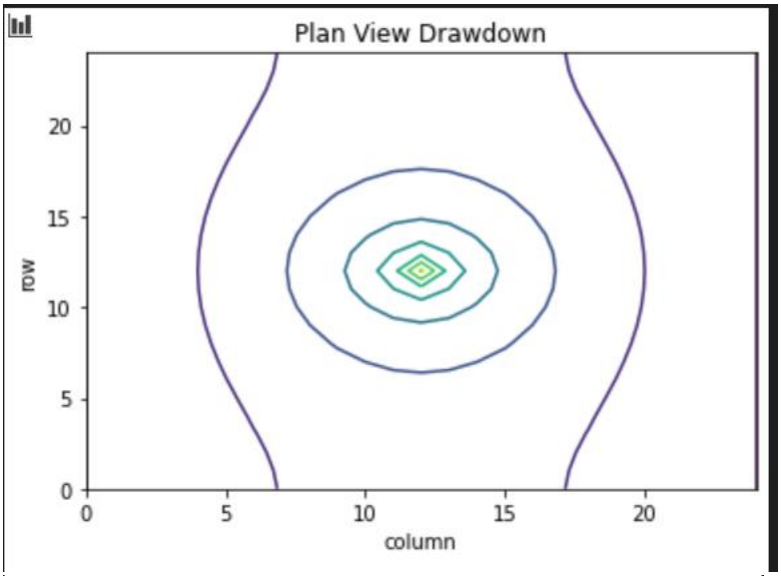
5. Move the well to [0,5,5]. Use all plots necessary to describe fully how water is flowing through the domain with the well in this location. Be sure to include the drawdown plot in your discussion - compare this plot to the equipotential and flow vectors. Something is not right about how the well location is shown. Fix it and explain what was wrong!!

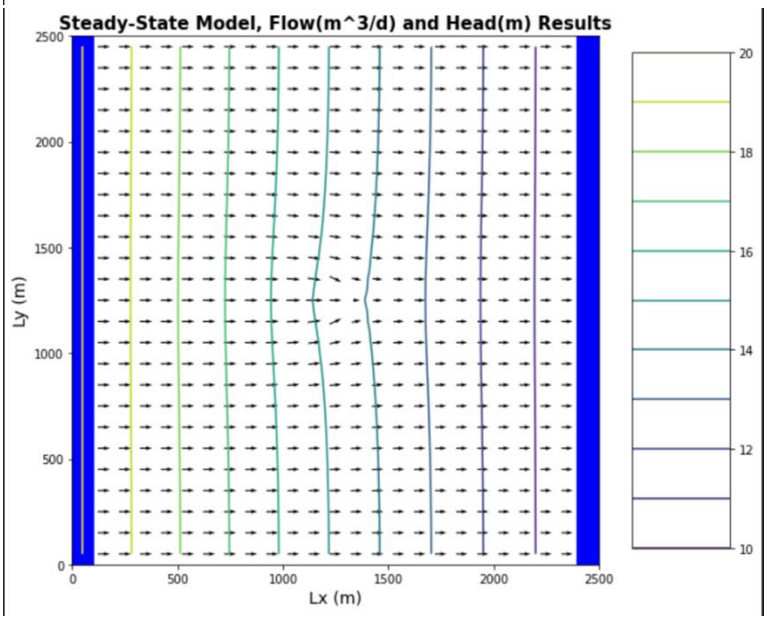
We see that the plan view and the steady-state view are not the same system because of a coding issue. The plan view shows the flow increasing towards the bottom of the left boundary as the well is in that area. An increase in flow around the well makes sense as we see with the traffic jam analogy, the water around the well accelerates around the well as well as goes into it, and the further right away from the well, we see a decrease in flow values as the background head gradients starts to take over again. The right boundary does almost nothing as it is far away from the well. The flow slightly increases towards the top of the right boundary as the background head is higher than the head that is created after the well has been in touch with the flow from the left. The center is slightly affected by decreasing slightly in flow as it is also far away from the well but takes the effect of the decrease in flow values from the resulting well impacts. When we "fix" the graph to [0,20,5] we finally see the plan view from [0,5,5] match with the steady-state equipotential model. This is because modflow and python swap orders of direction as they count rows from bottom to top and then top to bottom while

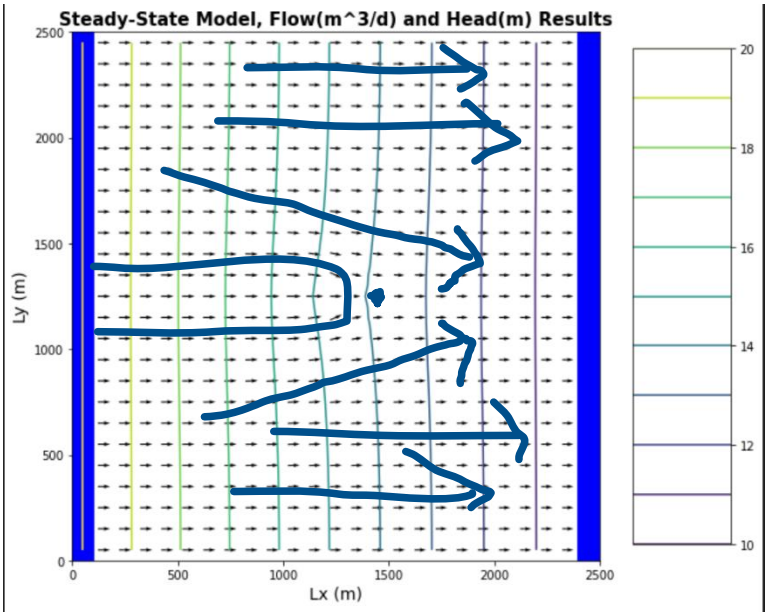
creating the plan view vs the steady-state equipotential view at the same point. ***----In the center transect with the center boundary, we see a general slight decrease in flow values and gradual increase as we enter and exit the well. Overall, the flow values are pretty low. We see a general increase in flow values with the right boundary but also with overall, low flow values. In the left boundary however, we see a sharp increase in flow values and then large but gradual decrease in flow values once it hits the well. The head values in the equipotential graph show similar characteristics of the previous location of [0,12,12] which does not really follow the flow graph. Not really sure what is wrong with the well or why it is doing this.***

With center values, [0,12,12] flux of -10 and centered (at 12):




Plan View Drawdown
row
column
0
5
10
15
20


Steady-State Model, Flow(m^3/d) and Head(m) Results
Ly (m)
Lx (m)
0
500
1000
1500
2000
2500
10
12
14
16
18
20



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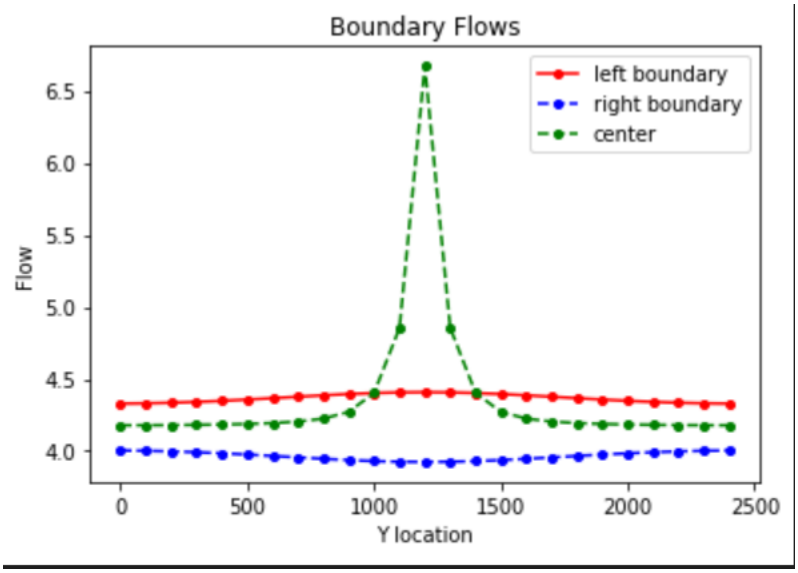

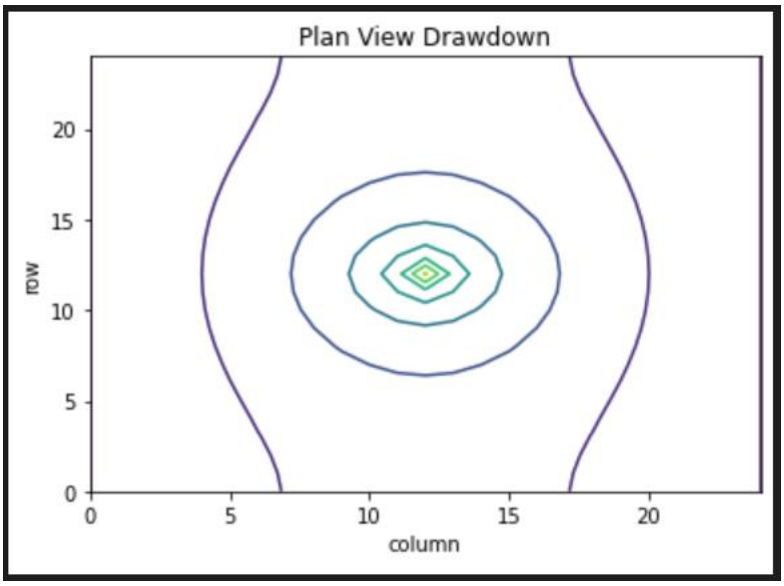
Plan View Drawdown
row
column
0
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10
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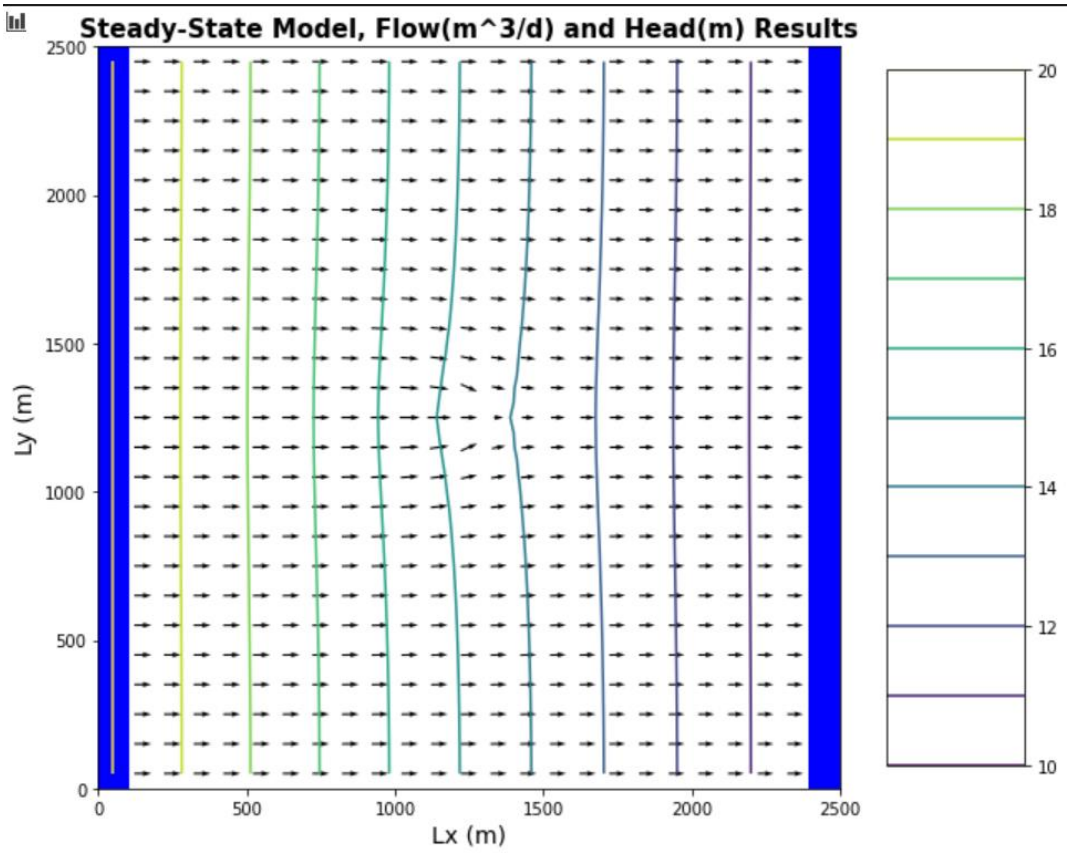
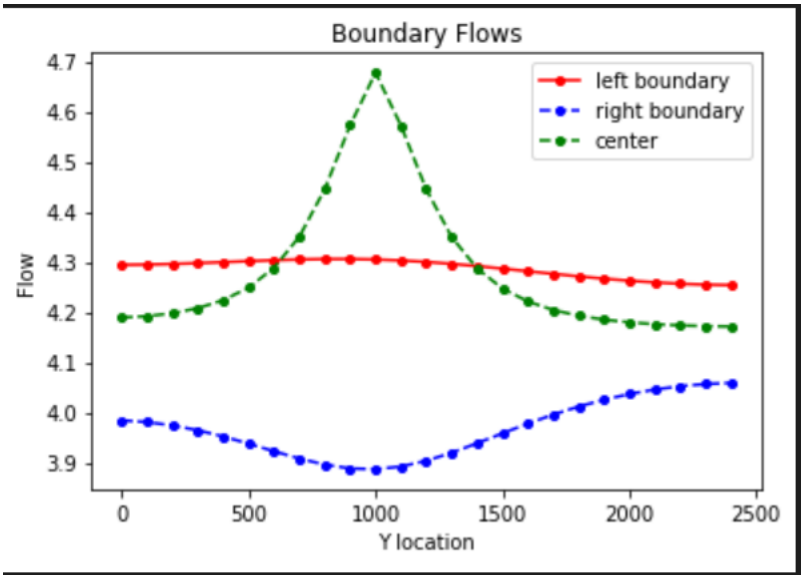
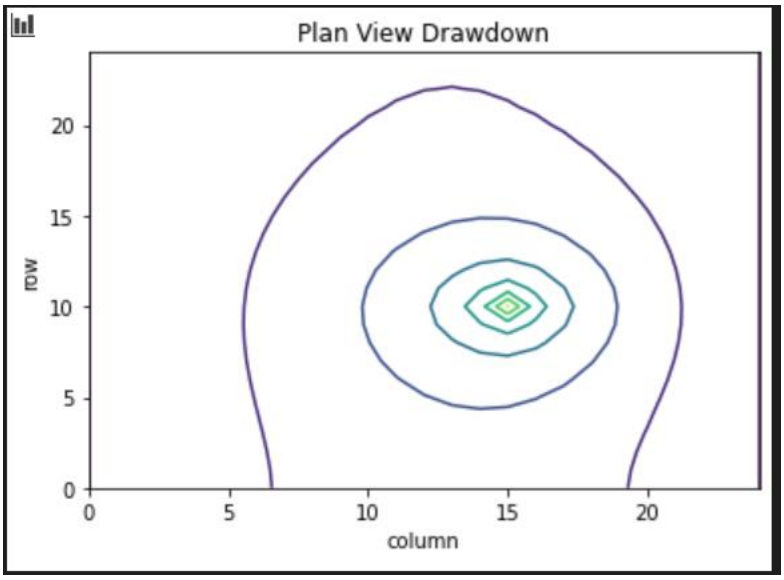
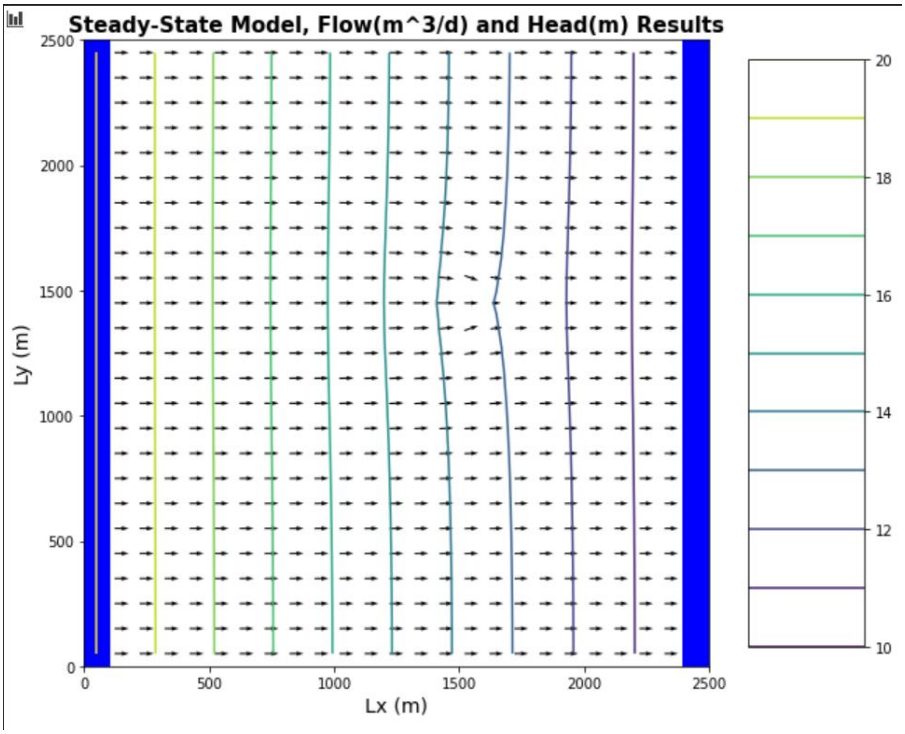

Steady-State Model, Flow(m^3/d) and Head(m) Results
Ly (m)
Lx (m)
0
500
1000
1500
2000
2500
10
12
14
16
18
20

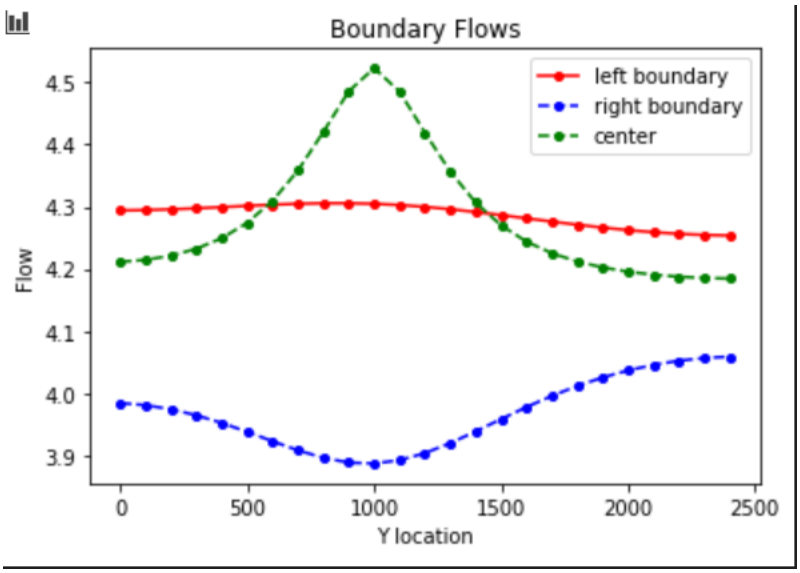
With center values, [0,10,15] flux of -8 and centered (at 12):

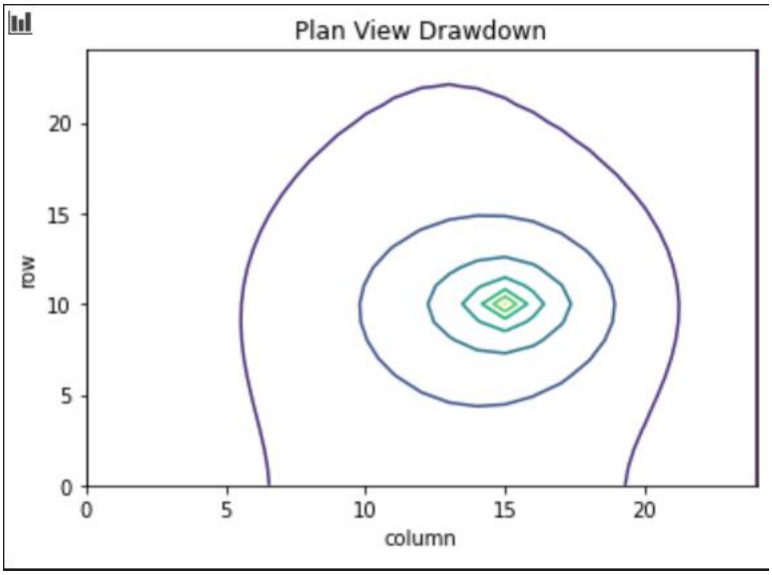






With center values, [0,10,15] flux of -8 and not centered (at 11):


Boundary Flows
left boundary
right boundary
center
Flow
Y location
4.5
4.4
4.3
4.2
4.1
4.0
3.9
0
500
1000
1500
2000
2500


Plan View Drawdown
row
column
20
15
10
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15
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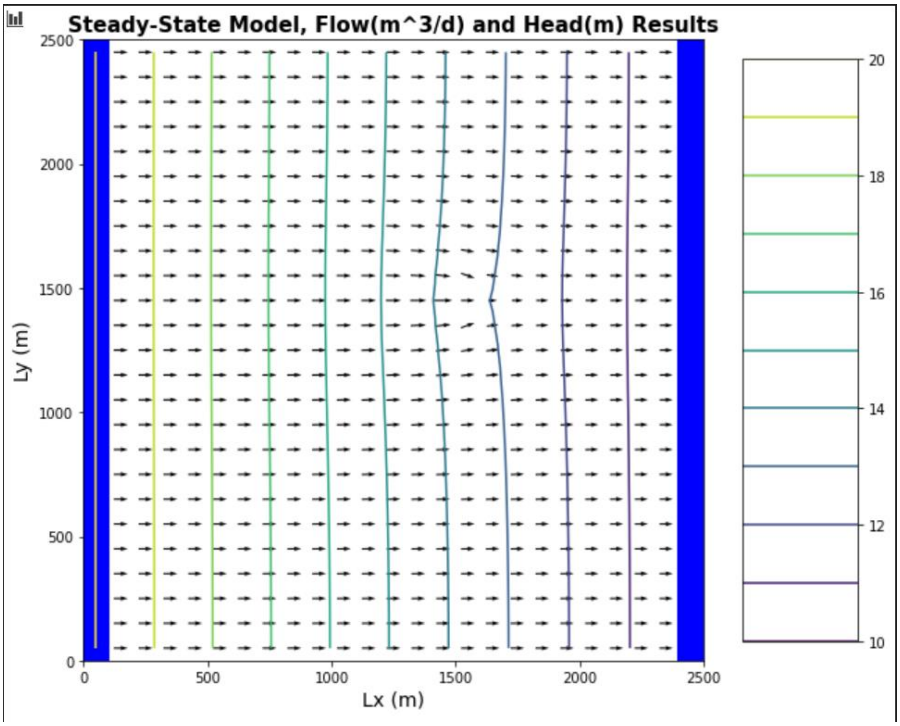
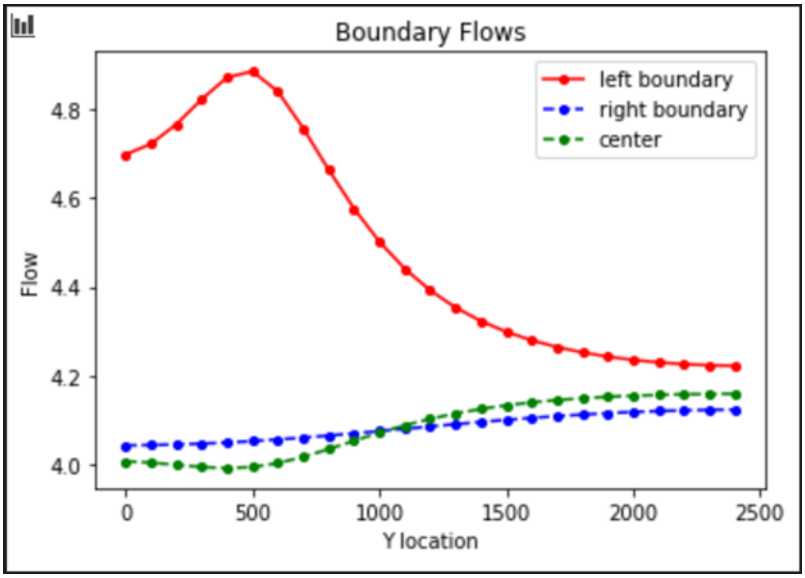
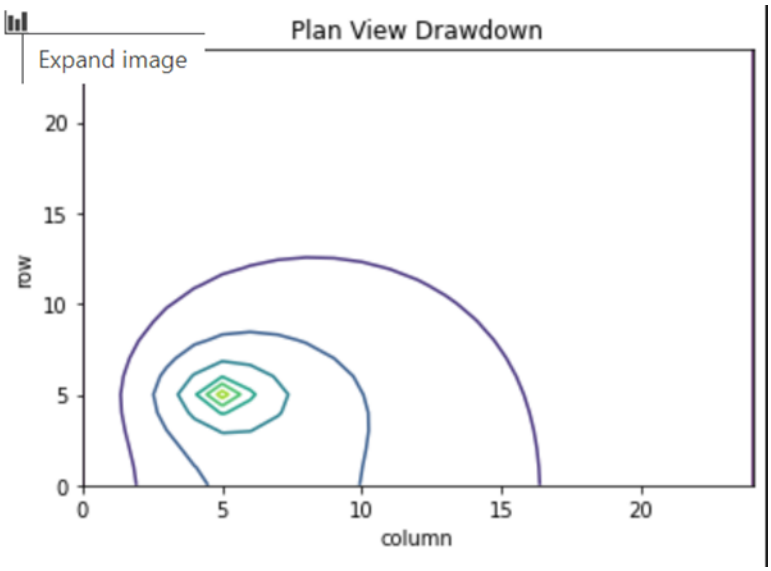
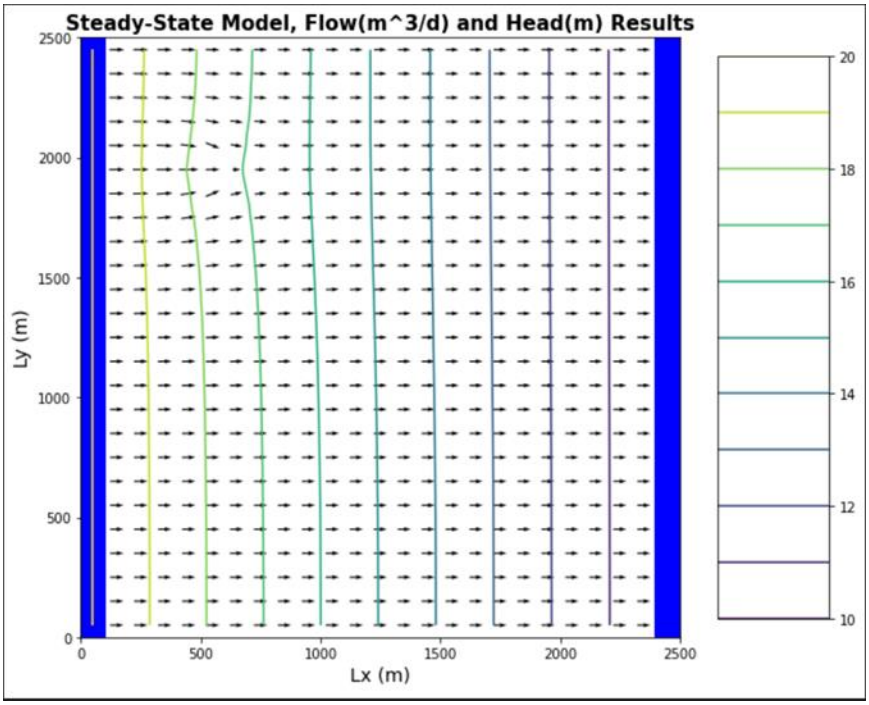


With center values, [0,5,5] with flux of -10 and centered (at 12):







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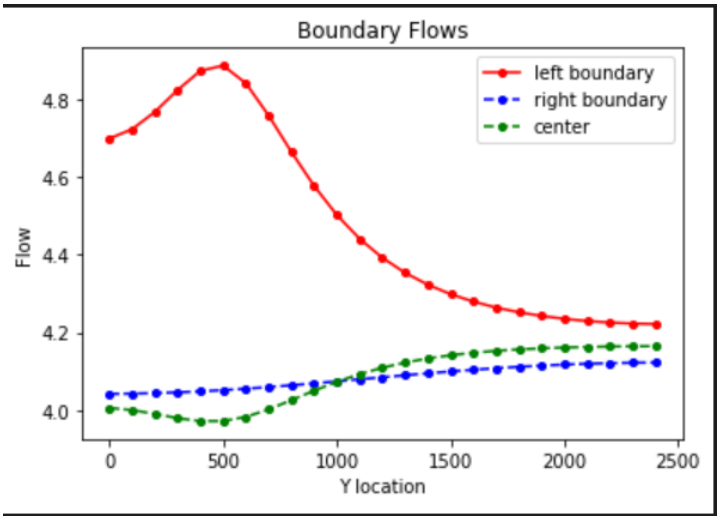
Boundary Flows
left boundary
right boundary
center
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4.8
4.6
4.4
4.2
4.0
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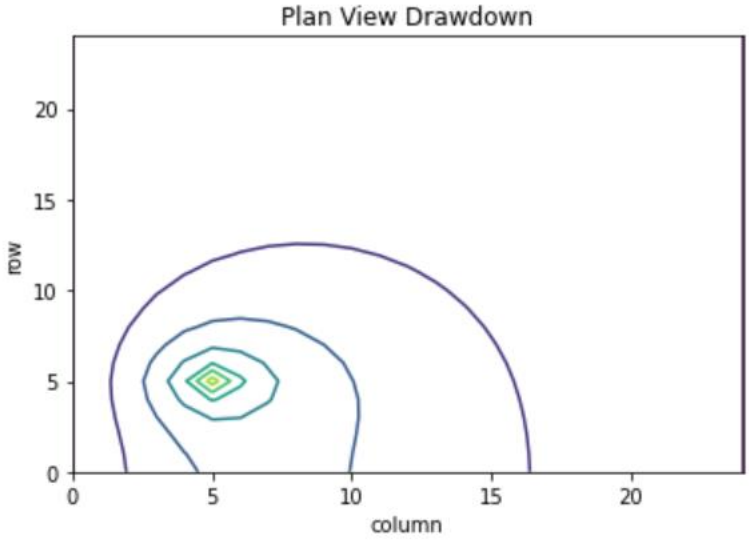
Y location


Plan View Drawdown
row
20
15
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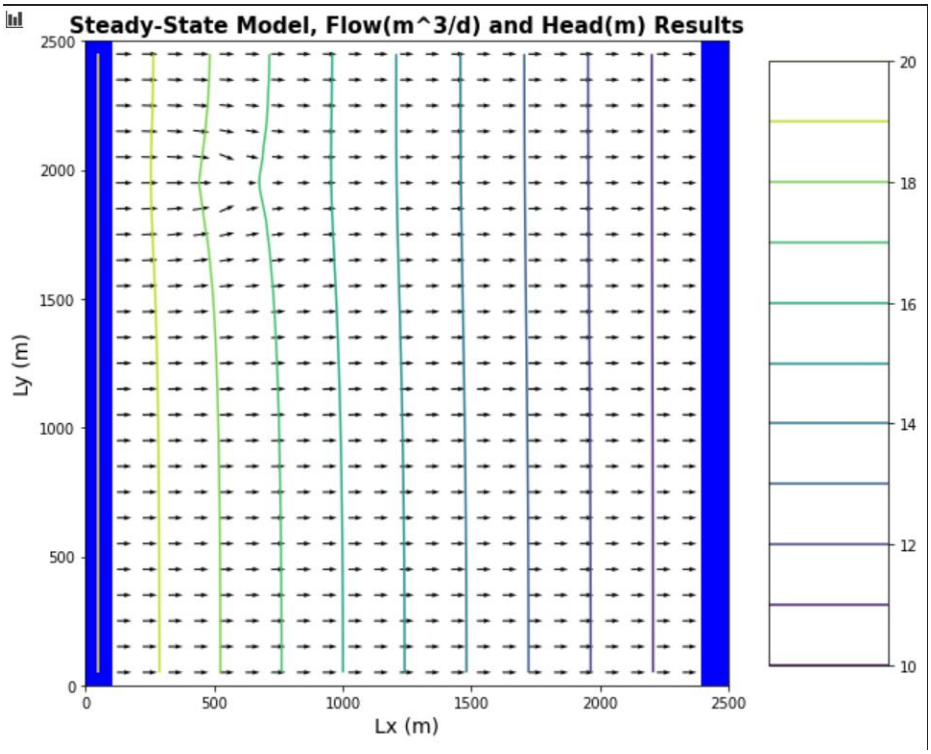
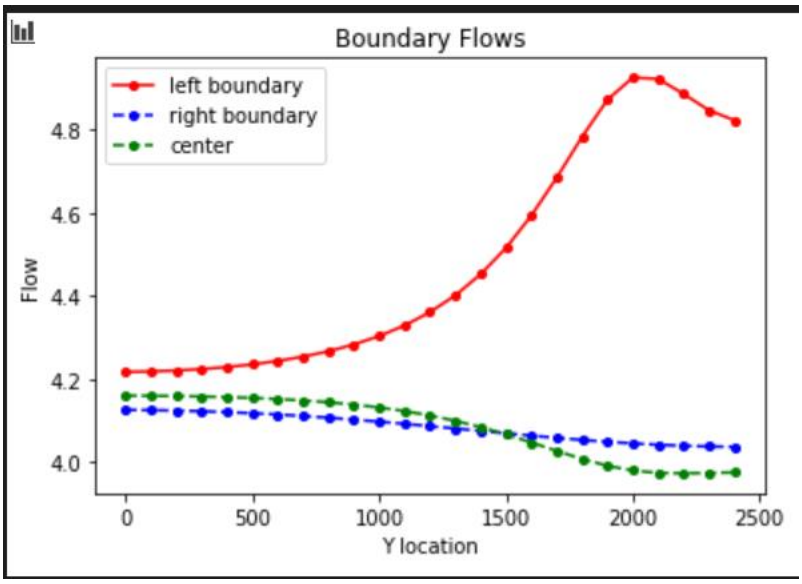
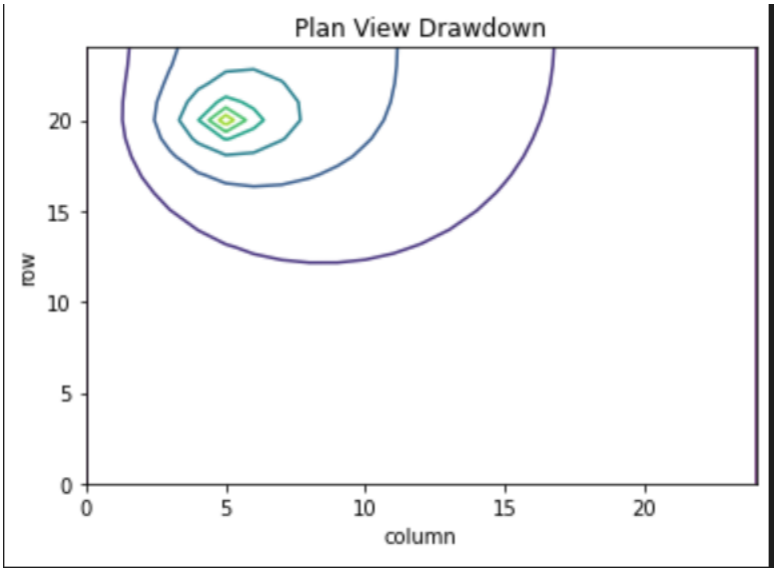
column



(FIXED)

With center values, [0,20,5] with flux of -10 and centered (at 12):

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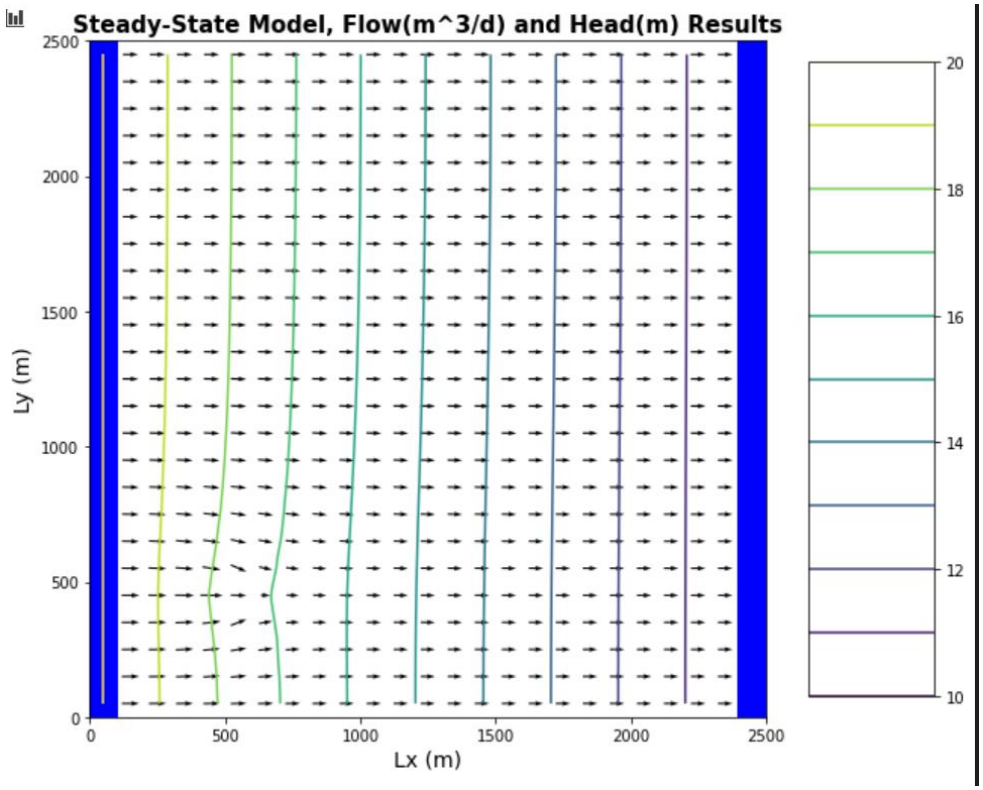
Steady-State Model, Flow(m^3/d) and Head(m) Results
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