Week 4.

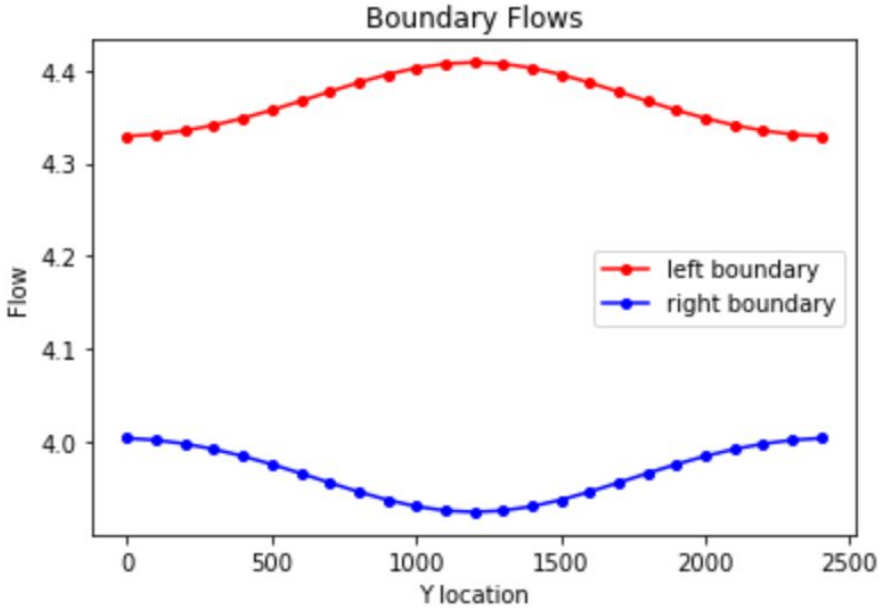
FloPy Box Model with Pumping Well

Jen, Katarina, Xenia

Challenge #1 The well is located at [0,10,15] in the starter code and it is withdrawing water at a rate of -8 m3/day. The first challenge is to move the well at the center of the domain [0,12,12] and change rate -10 m3/day.

Challenge #2 For the initial well location, plot the total flow into the left (constant head = 20) and out of the right (constant head = 10) boundaries.

- Explain why the flow 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.
- Are you still modeling steady-state conditions? So, what is supplying water to the well?



- Boundary flows are not constant along them because we instead, have a constant head along them, so our flow will vary depending on the location to maintain the same head along.
- The flows are not the same in the right and left boundaries because there is now a pumping well extracting water in the middle of the domain with a rate of -10m3/day, for that reason the flow downstream of the well is lower. The distribution of the flow is higher in the center for the left boundary because there is a well in the center attracting all the water into it, so the left boundary is perceiving that increase on the velocity of water. On the other hand, the right side has a decrease of flow in the center because it is perceiving the extracting water effects of the well located in that center area.
- We are modelling steady state conditions, because the flow entering the left boundary is equal to the sum of the flow out which in this case will be the left boundary flow + the pumping well rate.

```
Left Flow = 109.166664  Right Flow= 99.166664  Difference = -10.0
```

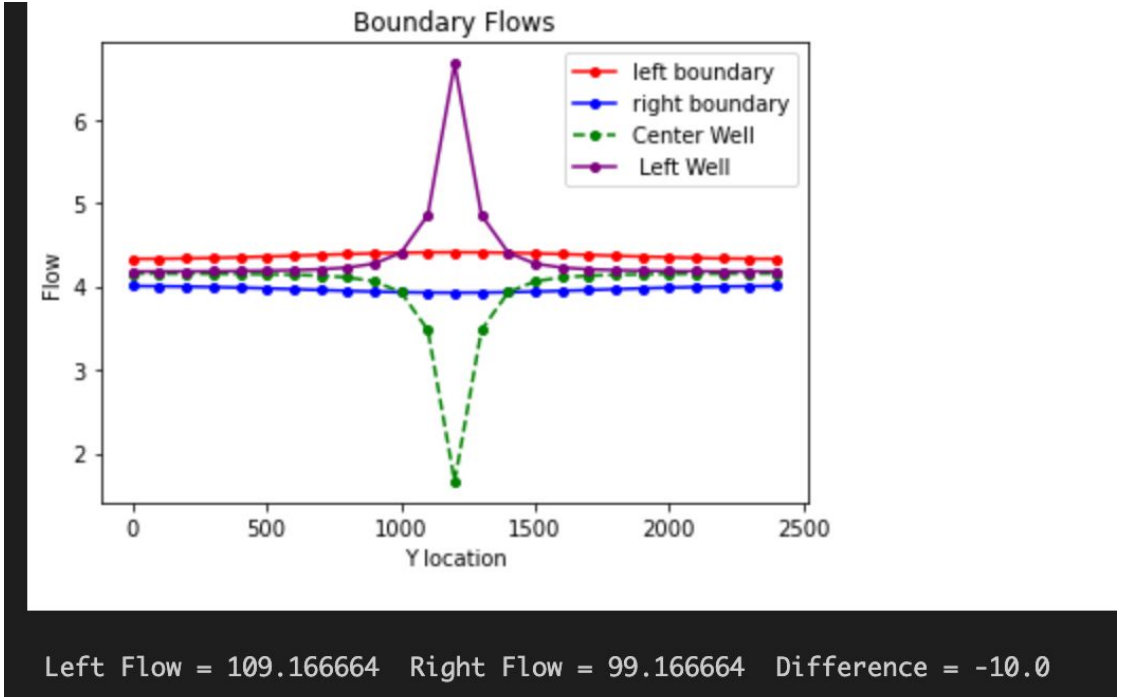
Challenge #3

Plot series of the flow left-to-right along a vertical line that passes through the center of the well [:,12]

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

Well location: [0,12,12]

- The difference between flows is the value of the pumping rate.
- With the added vertical line through the center of the well, we can see how flow decreased along the transect, because the well is extracting water in the middle of the domain.
- However, when we moved the line before the location of the well we can see how flow is higher along the left boundary since is getting near to the pumping well.



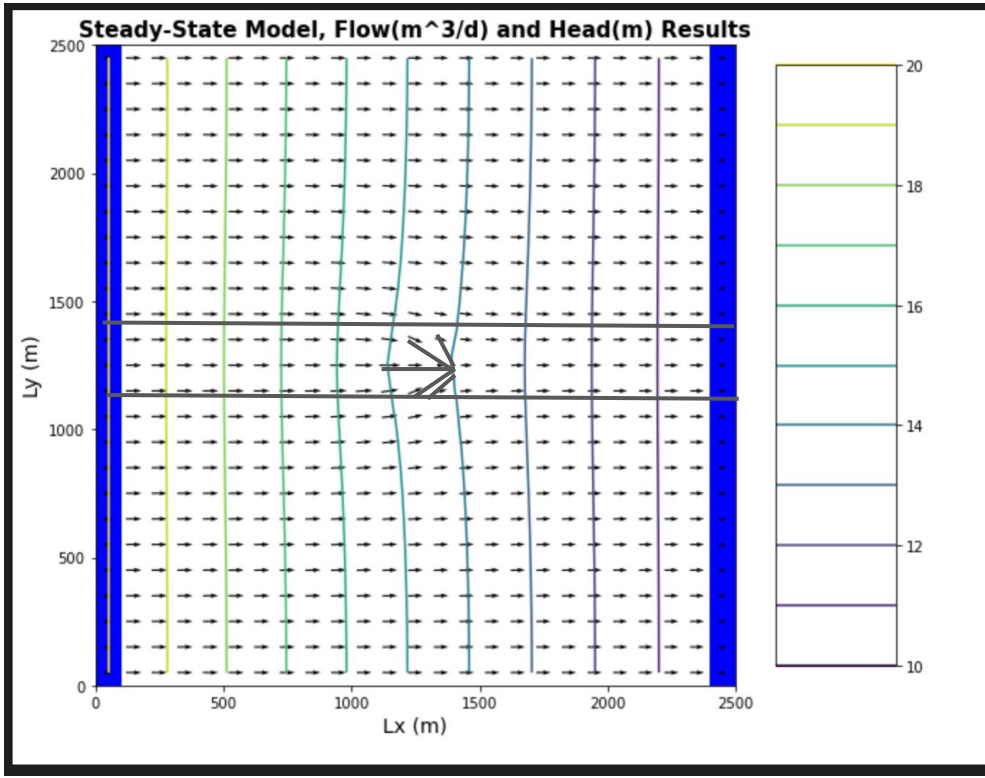
Challenge #4

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.

Challenge #4

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.

- Water flows laterally and vertically through the domain (ie x and y direction)
  - Lateral flow in top and bottom
  - Vertical/ additional flow angles near the well as it is a sink
- Water that is extracted by the well comes from the area between 1100-1300 m or grid cells 11-13

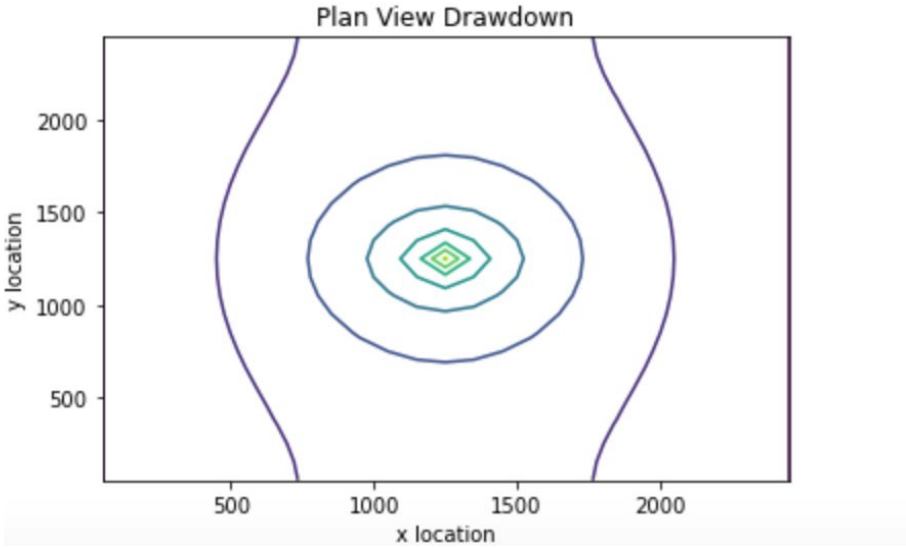


Challenge #5

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.
- Why are the drawdown contours not equally spaced?

Well location: [0,12,12]



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

- Well is a vortex drawing water into it
  - Impact propagates out into the surrounding area
  - Not circular because we have lateral flow (y direction)

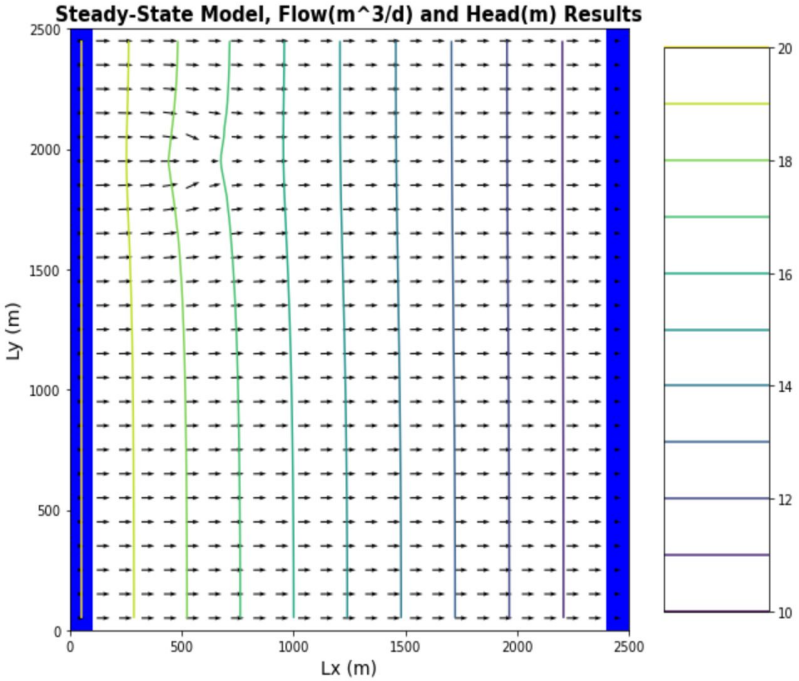
Why are the drawdown contours not equally spaced?

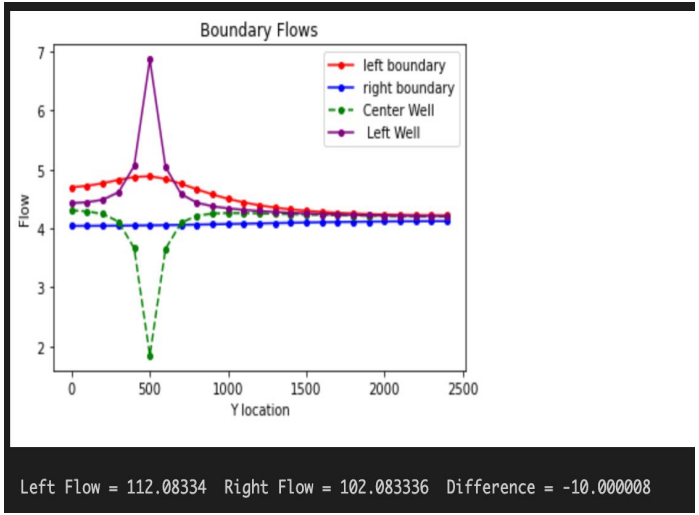
- Area close to the well will feel more impact than area far away
- Some flow lines will not be impacted due to distance from well
  - Higher impact = closer lines

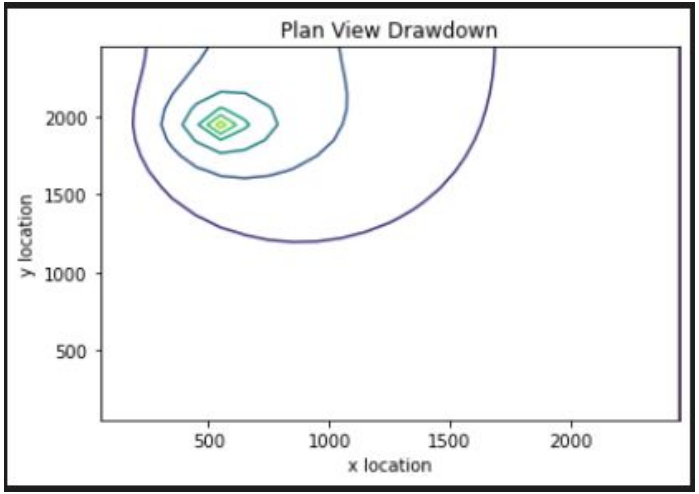
Challenge #6

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.

Well location: [0,5,5]



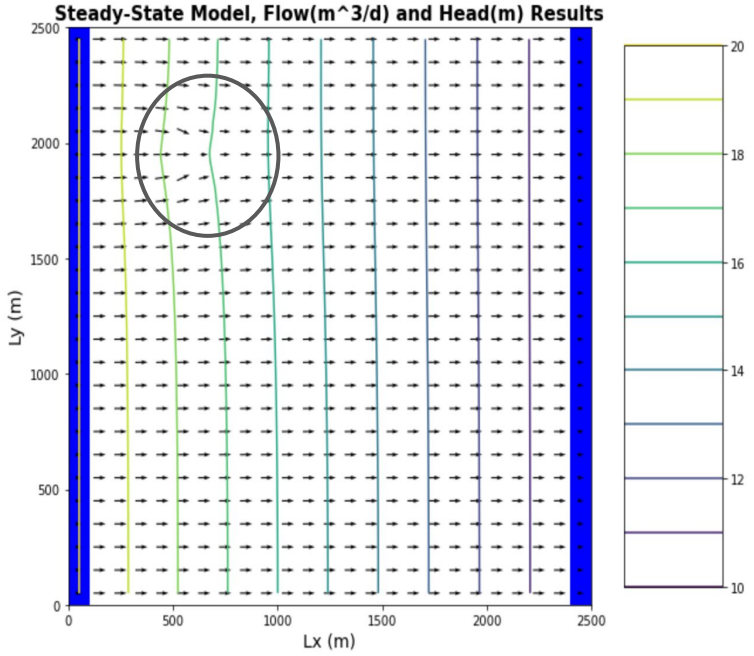


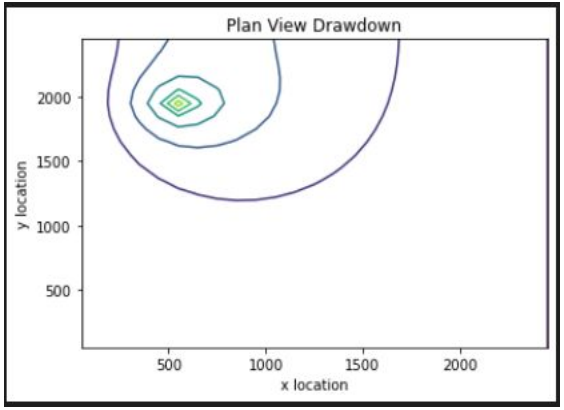


Challenge #6: Answer

Water is flowing:

- Left to right
- Bottom half is less impacted by the well
- Top half moves in a semicircle
  - Flow lines either end in the well or traverses around the well
  - Similar to orbiting planets





BONUS: 1a Pumping Rate of -5 m^3/day

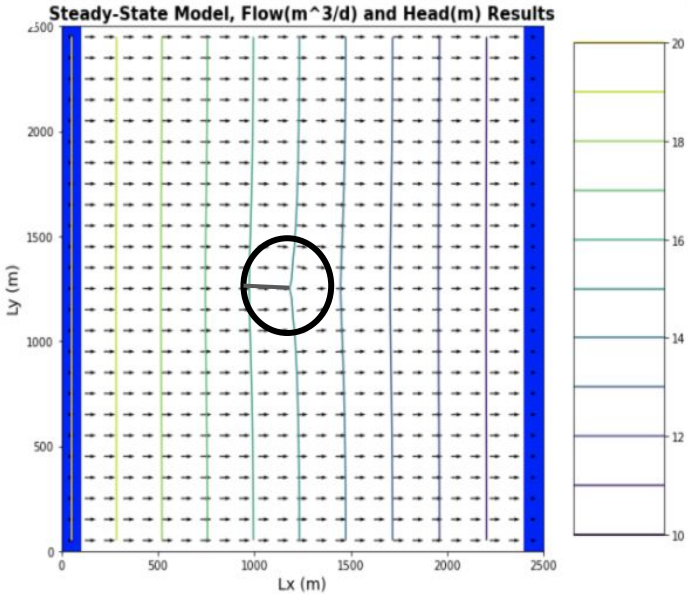
Question for you all: What do you think would happen?

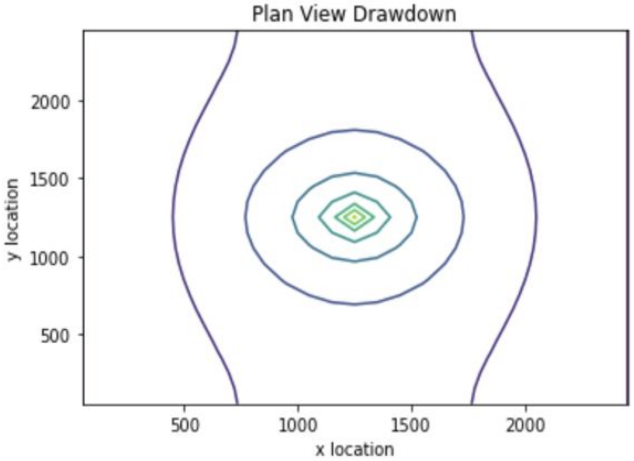
Well location: [0,12,12]

BONUS: 1a Pumping Rate of -5 m^3/day

Question for you all: What do you think would happen?

- Perturbation occurs in center of well
- Drawdown is quite small
- Most of the flow lines are not impacted






```
Left Flow = 106.66666  Right Flow= 101.666664  Difference = -4.9999924
```

BONUS: 1b Pumping Rate of -20 m^3/day

Questions for you all:

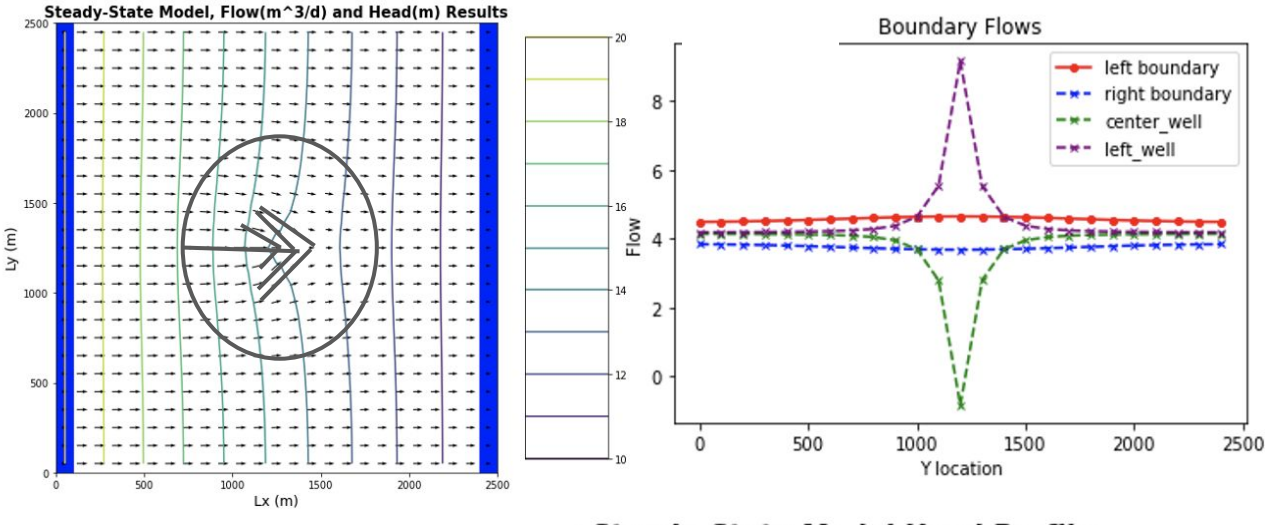
- What do you think would happen?
- Will it be more or less than the -5 m^3/day

Well location: [0,12,12]

BONUS: 1b Pumping Rate of -20 m^3/day

Question for you all: What do you think would happen? Will the flowlines spread our or be closer?

- More flow lines are impacted
  - Larger area
- High flow around the well




```
Left Flow = 114.16667  Right Flow= 94.166664  Difference = -20.000008
```

BONUS: 1c Pumping Rate of -25 m^3/day

Questions for you all: What happened?

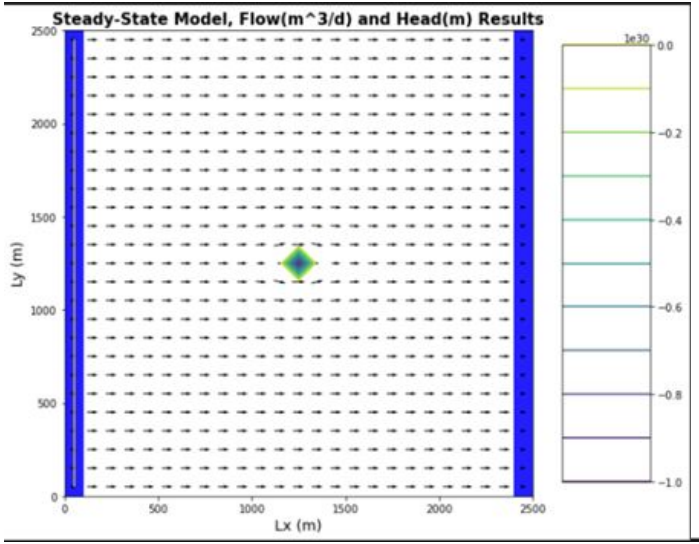
Well location: [0,12,12]

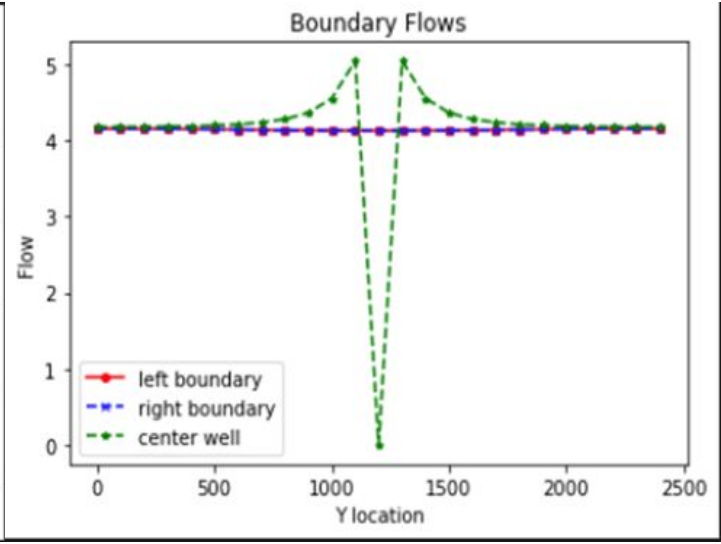
BONUS: 1c Pumping Rate of -25 m^3/day

Question for you all: What do you think would happen?

Answer:

- Drastic change in head in just one cell.
- Flow lines avoiding the pumping well site?
- Increase on the flow magnitude in the surroundings of the well to maintain the head equilibrium?

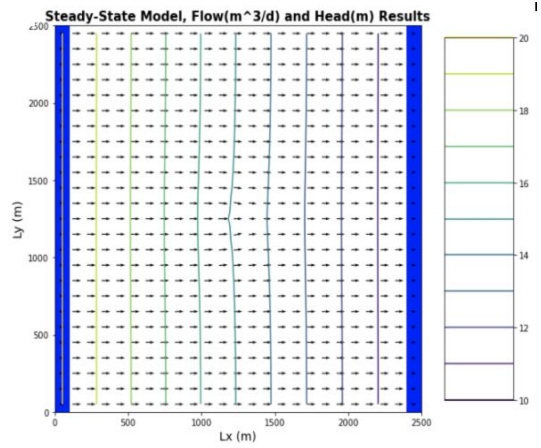




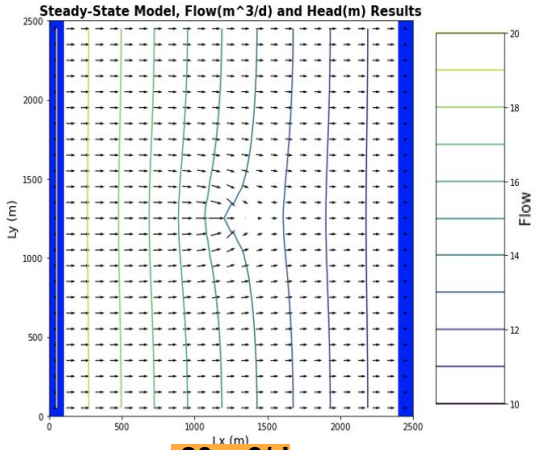

```
Left Flow = 103.62275  Right Flow= 103.62276  Difference = 7.6293945e-06
```

Why did this happen? The pumping rate in this case was so high that it drained all the water stored on that cell where the well was located in the immediate time.

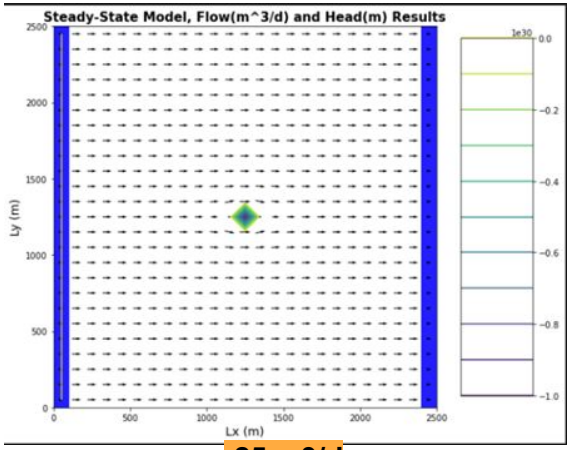
Comparison of the 3 cases



-5 m3/d



-20 m3/d



-25 m3/d