Henry Problem with Model Muse and MF6/Buoyancy package.

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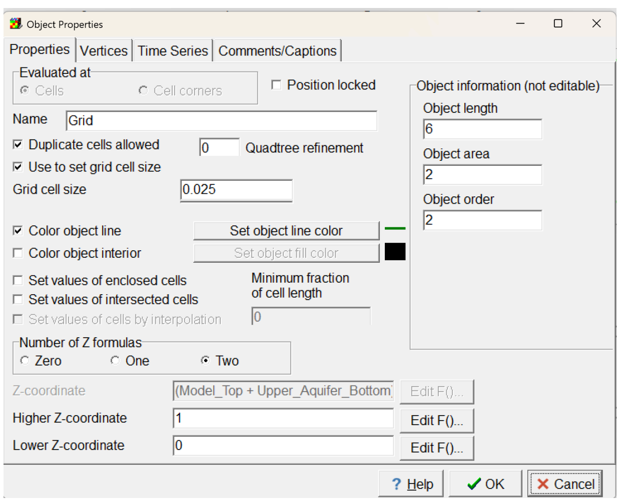
FLOPY VERSIONs:

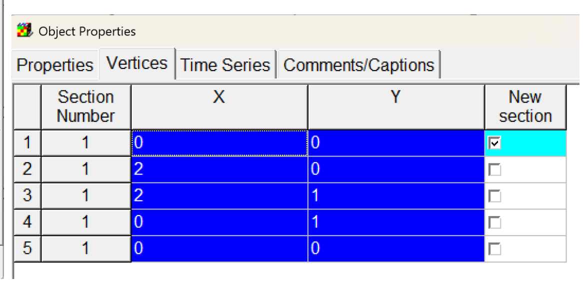
1. USGS: https://modflow6-examples.readthedocs.io/en/latest/_notebooks/ex-gwt-henry.html#Define-parameters
2. This one is edited from USGs version, but shows the density slope/calculation: https://deltares.github.io/imod-python/examples/mf6/Henry.html

New Project□

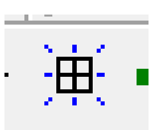
save, oftenly…

Draw a polygon to generate the grid: (make sure to check the "Use to set Grid cell size" box and give a value of 0.025.



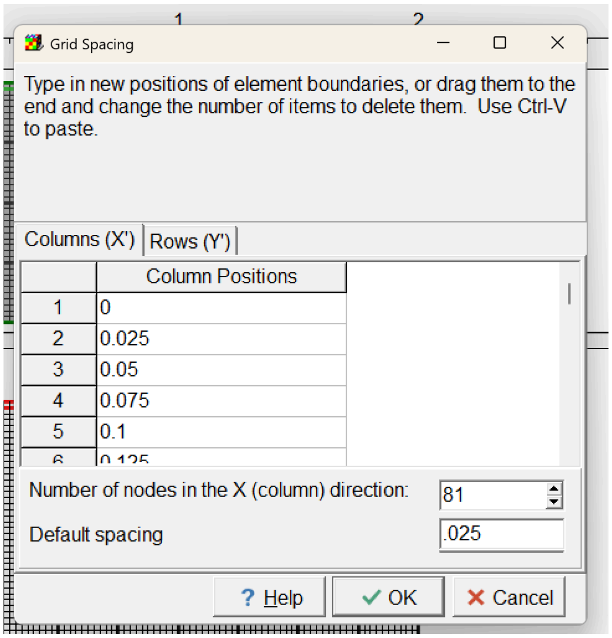


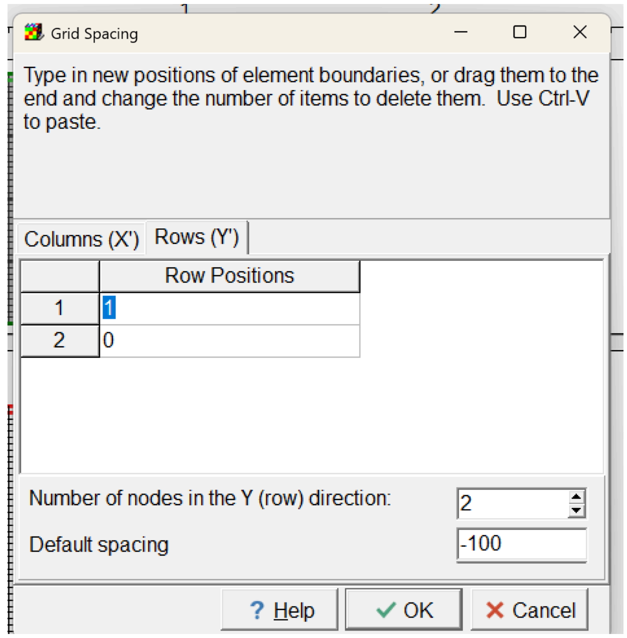
X	Y
0	0
2	0
2	1
0	1
0	0

Generate the grid: 

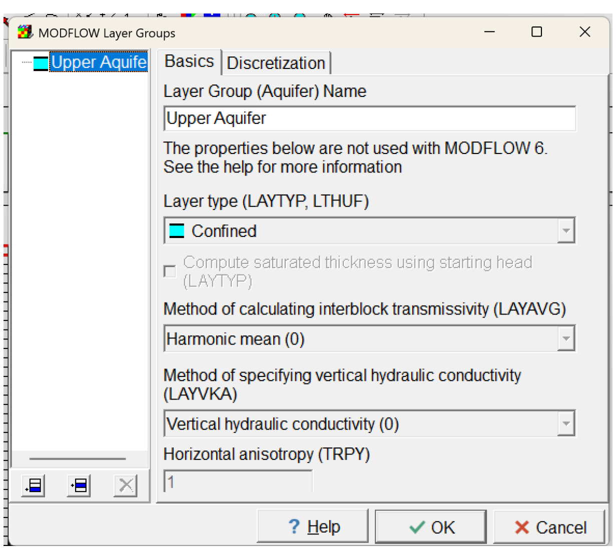
Adjust grid spacing to make only one row (two nodes), but 80 columns (81 nodes = n+1).

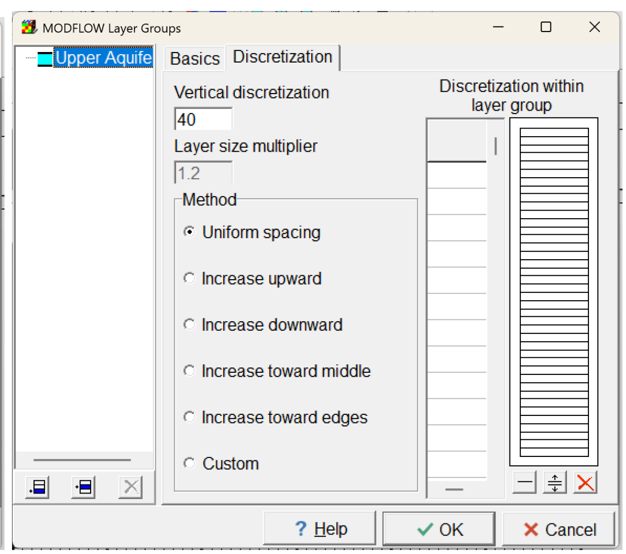
Also make sure you have only one row (Y) (2 nodes = n+1).

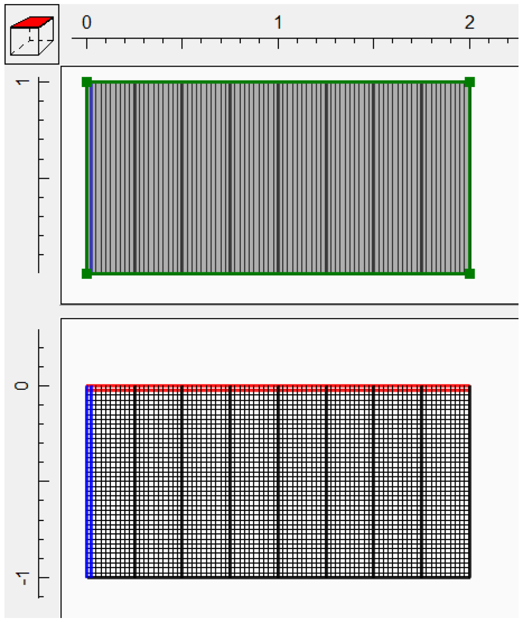




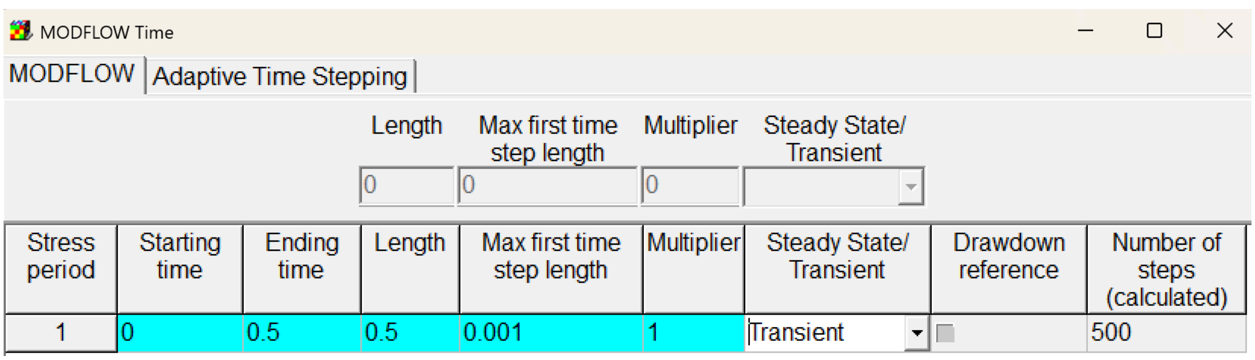
Model □ Model Layers: adjust to make 40 layers, equally spaced. You could alternatively set 40 layers, and manually set them as equally spaced, but because they're all same (no parameters vary between), easier to discretize a single "layer group" 40 times.

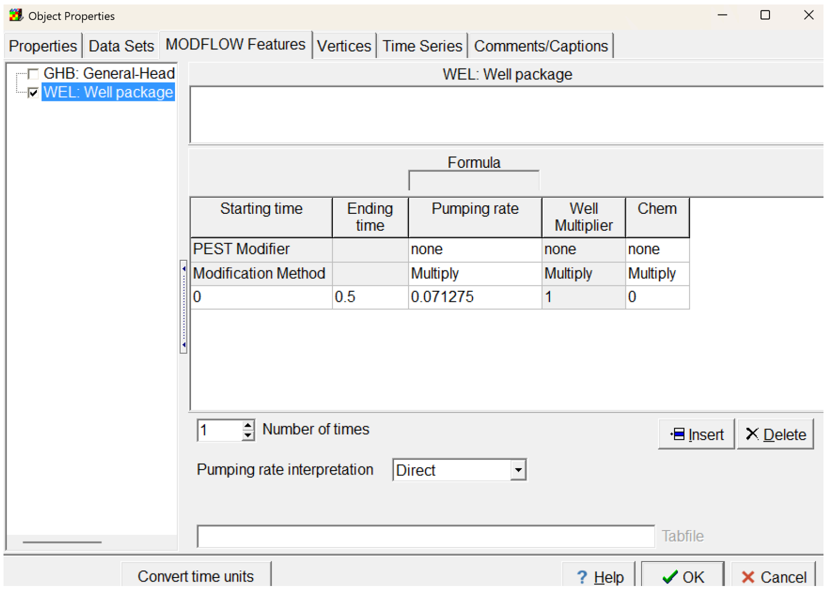


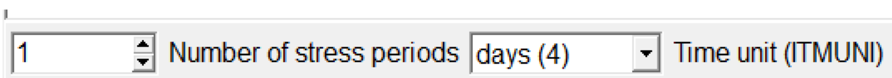


Looks like this: 

Make sure the top pane only has 1 row (not 40!)!!!



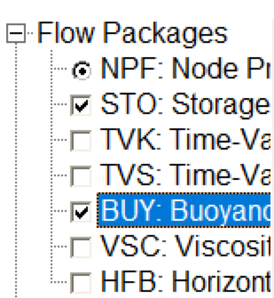


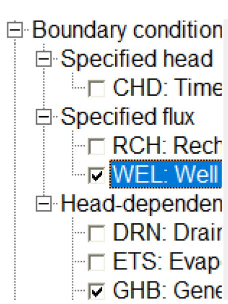


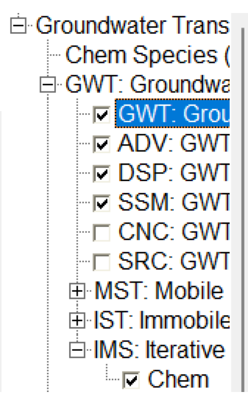
Model: Modflow Options:

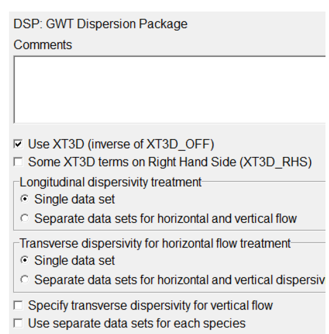
Model □ Packages and Programs

Turn on appropriate packages and adjust settings.







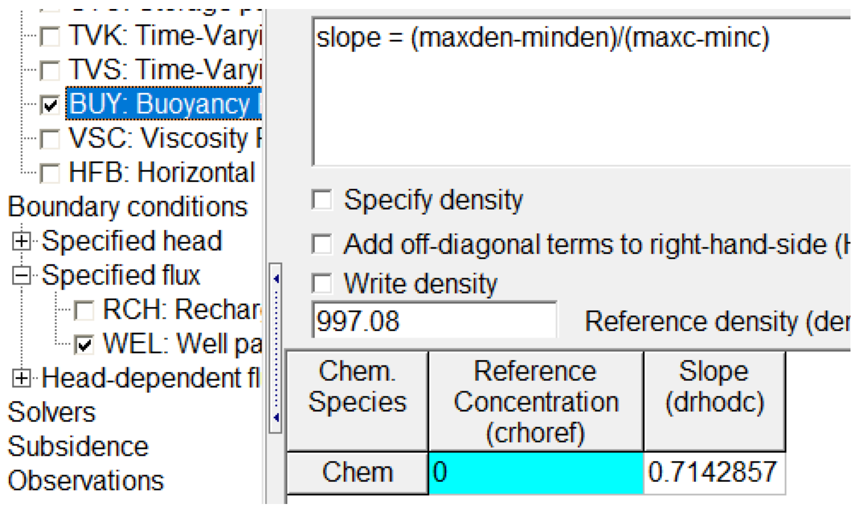


STO: set as Ss

BUY:

slope = (max_density - min_density) / (max_concentration - min_concentration)

(1025-1000)/(35-0)=0.7142857

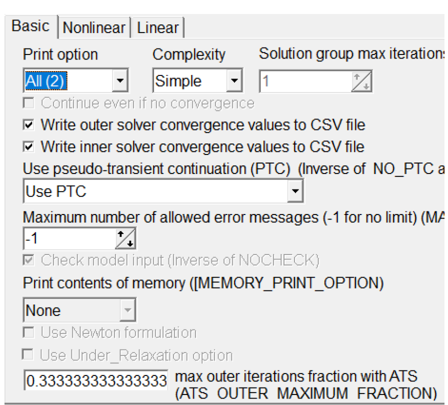


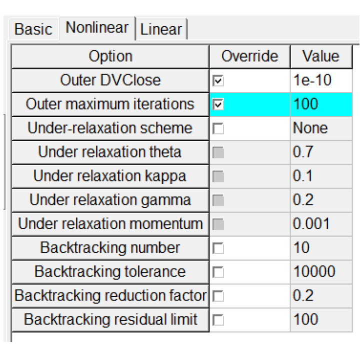
Solvers: Both 1) Solvers□IMS and 2) GWTransp□GWT□IMS

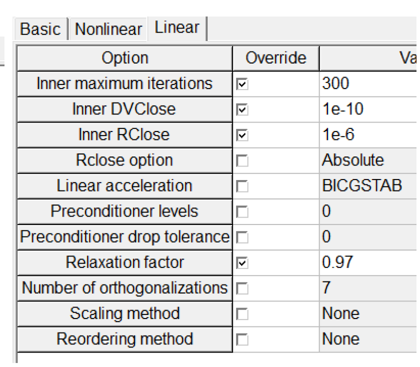
Solver criteria need to be pretty tight for decent pct discrepancy, not sure how tight, but the following are likely overkill (what was set in the USGS FloPy tutorial). Solution did require "BICGSTAB" as linear acceleration (and a checked override box next to it) for solution to converge.

```
print_option="ALL",
outer_dvclose=hclose,
outer_maximum=nouter,
under_relaxation="NONE",
inner_maximum=ninner,
inner_dvclose=hclose,
rcloserecord=rclose,
linear_acceleration="BICGSTAB",
scaling_method="NONE",
reordering_method="NONE",
relaxation_factor=relax,
```

```
nouter, ninner = 100, 300
hclose, rclose, relax = 1e-10, 1e-6, 0.97
```







Data “Edit data sets”: Sets these values globally instead of using a polygon.

Layer_Definition:		
Model Top	1	m
Model Bottom	0	m
GWT:		
Longitudinal_Dispersivity	0.57024	m2/d
Horizontal_transverse_Dispersivity	0	m2/d
Hydrology:		
Modflow_Initial_Head	1	m
Kx	864.0	m/d
Ky	=Kx	m/d
Kz	=Kx	m/d
Porosity	0.35	-
Specific_Storage (default)	1E-5	/m
MT3DMS:		
Initial_Concentration_Chem	35	-
Longitudinal_Dispersivity	0	m2/d?

```
hydraulic_conductivity = 864.0  # Hydraulic conductivity ($m d^{-1}$)
```

Values from FloPy tutorial…

```
ghbcond = hydraulic_conductivity * delv * delc / (0.5 * delr)
ghbspd = [[(k, 0, ncol - 1), top, ghbcond, 35.0] for k in range(nlay)]
flopy.mf6.ModflowGwfghb(
    gwf,
    stress_period_data=ghbspd,
    pname="GHB-1",
    auxiliary="CONCENTRATION",
)

welspd = [[(k, 0, 0), inflow / nlay, 0.0] for k in range(nlay)]
flopy.mf6.ModflowGwfwel(
    gwf,
    stress_period_data=welspd,
    pname="WEL-1",
    auxiliary="CONCENTRATION",
```

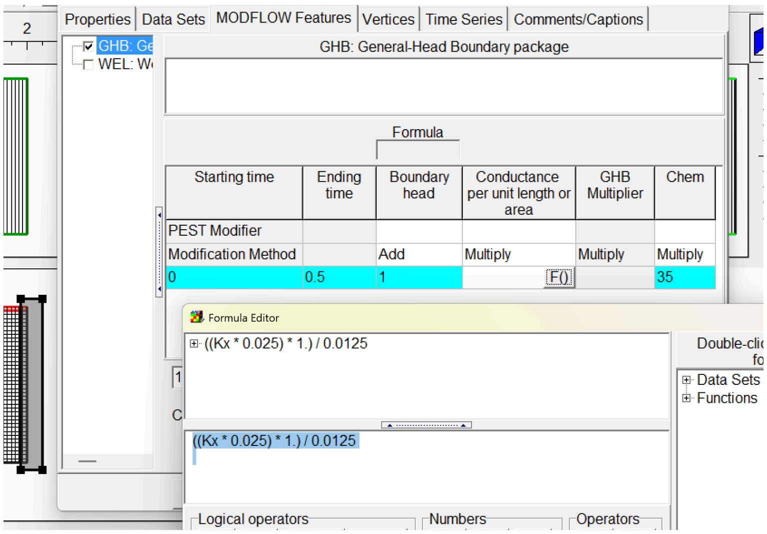
Well: inflow_a=5.7024, inflow_b=2.8512

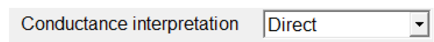
```
delr = 0.025  # Column width ($m$)
delc = 1.0  # Row width ($m$)
delv = 0.025  # Layer thickness
```

WELL:

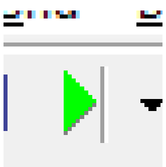
Double check your listing file at end to make sure well pumping rates are applied correctly—total rate should equal 5.7024. Above I take that value and divide by 40 to divide between the 40 layers.

GHB:

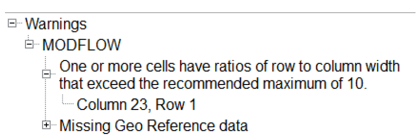




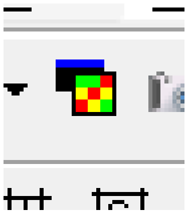
Don't forget to ***save, oftenly…***

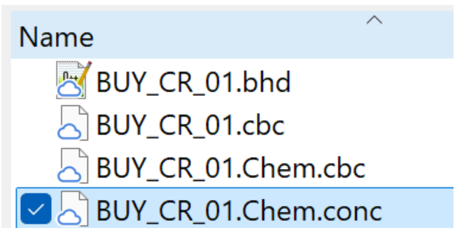
RUN it… 

Some warnings and errors I encountered…

- Warnings: 

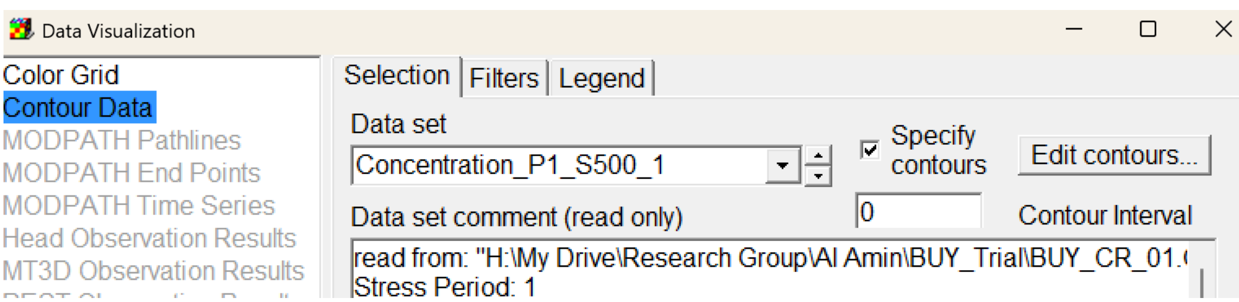
  - Nothing to be concerned about
- Errors: innerDVclose>= OuterDVclose
  - Sol'n: not sure this matters, but could adjust
- Error: "cehm produces asymmetric coef matrix, but conj. Grad/ meth was selected,
  - Sol'n use "BICGSTAB" instead" turned "BICGSTAB" back on…
  - https://water.usgs.gov/nrp/gwsoftware/ModelMuse/Help/sms_sparse_matrix_solution_pac.htm
    Linear acceleration: defines the linear acceleration method used by the default IMS linear solvers.
    CG - preconditioned conjugate gradient method.
    BICGSTAB - preconditioned bi-conjugate gradient stabilized method.

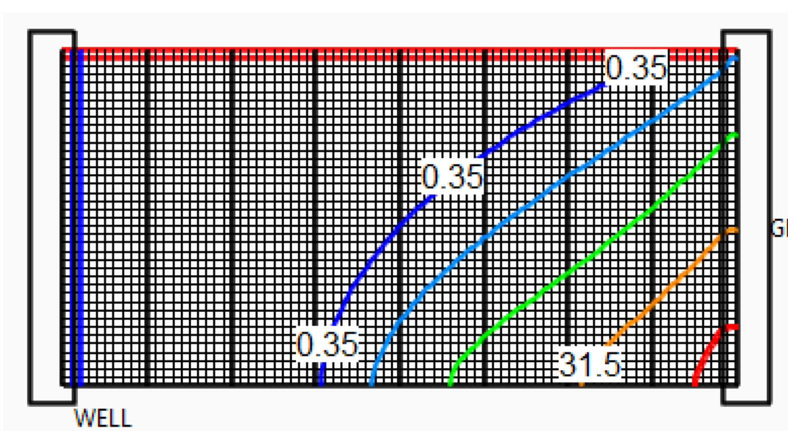
Plot data: 

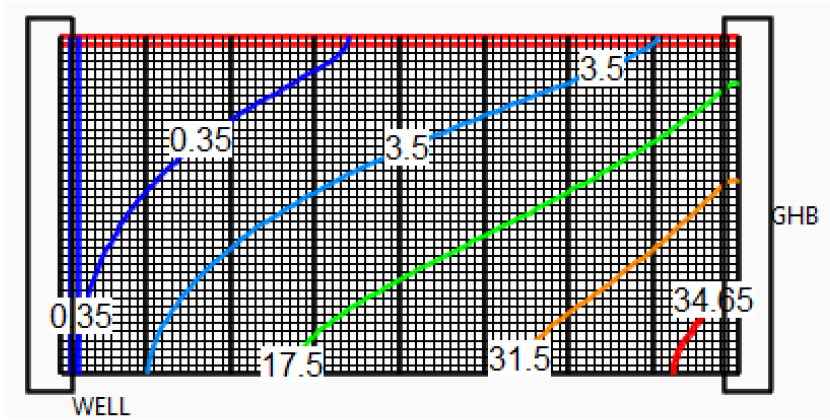


- bhd is heads, (binary heads)
- cbc is fluid fluxes, (cell-by-cell fluxes) – use for vectors…
- chem.cbc is chem fluxes, and (chem cell-by-cell)
- chem.conc is concentration (conc)

☐Adjust contours to 1%, 10%, 50%, 90% and 99%

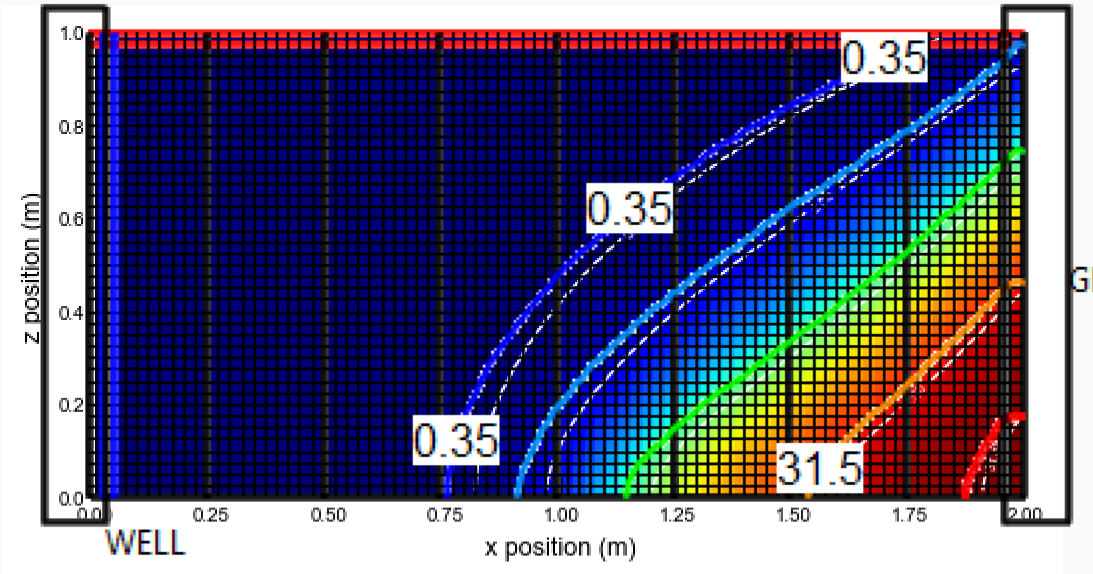


Inflow 1 : 

Inflow 2 : 

Overlay on top of benchmark to see a good match with the FLOPY Henry Mode

```
run_models took 6641.48 ms
```




```
Building model...ex-gwt-henry-b
run_models took 6788.65 ms
```