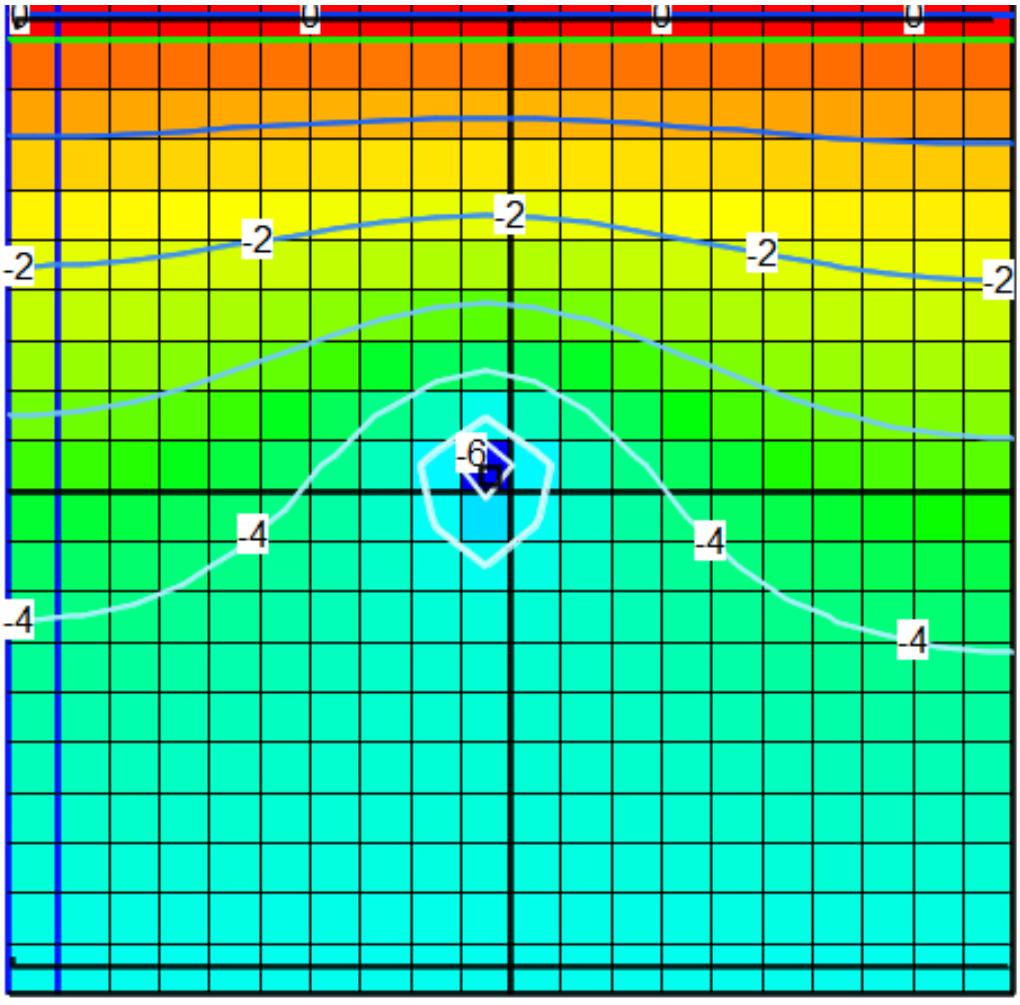
Groundwater modelling with Modflow 6 and ModelMuse

In this exercise you will create a simple groundwater model and use it to test how the hydraulic head is influenced by changes in hydraulic conductivity, pumping rate etc.



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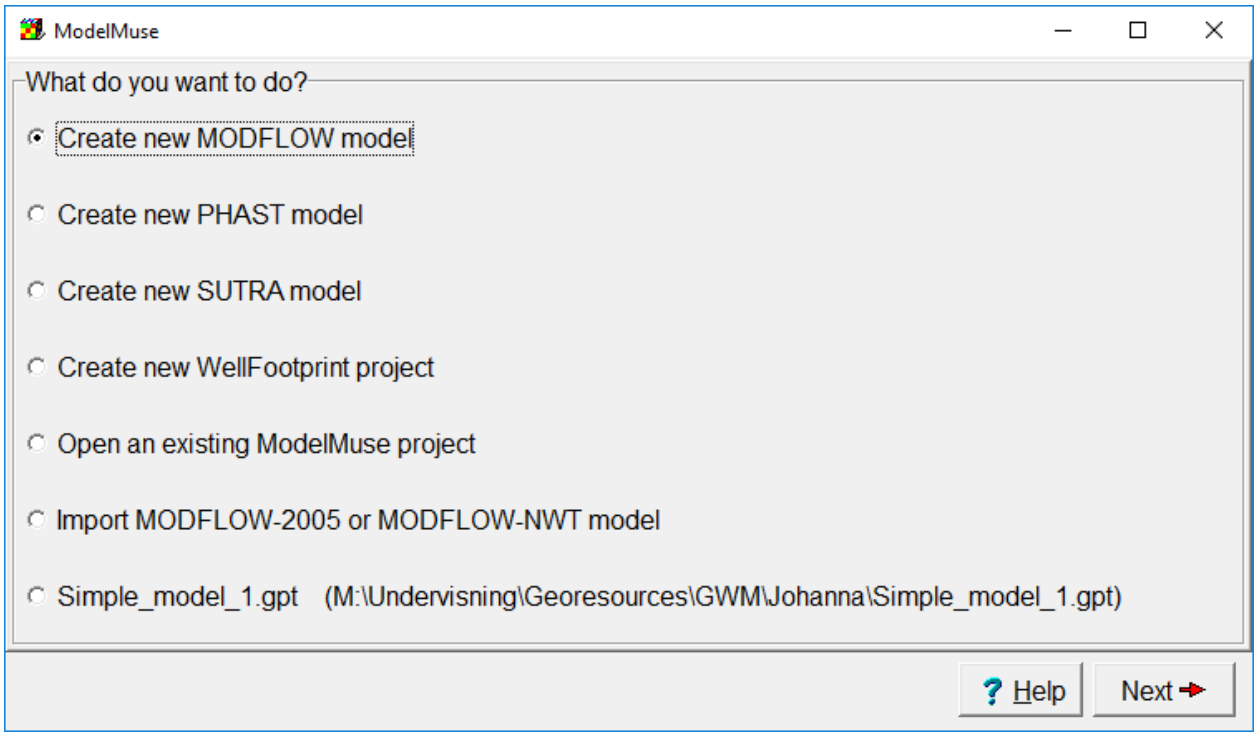
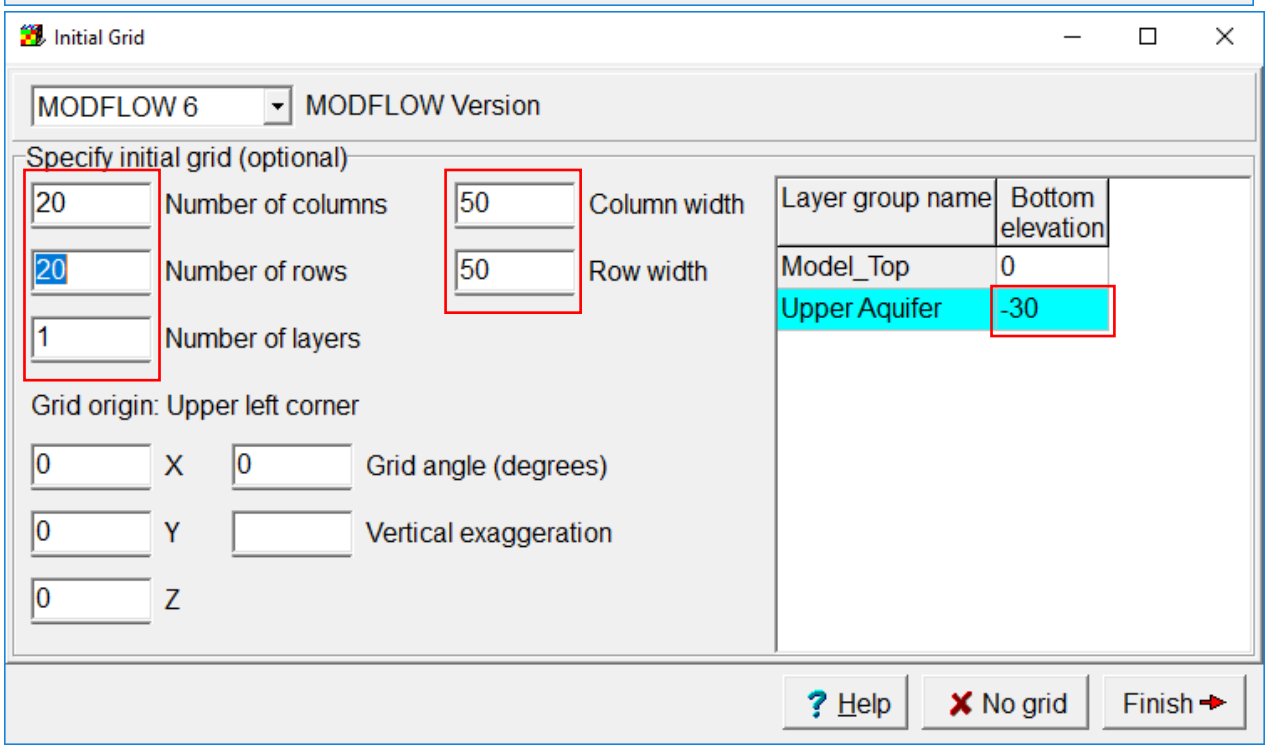
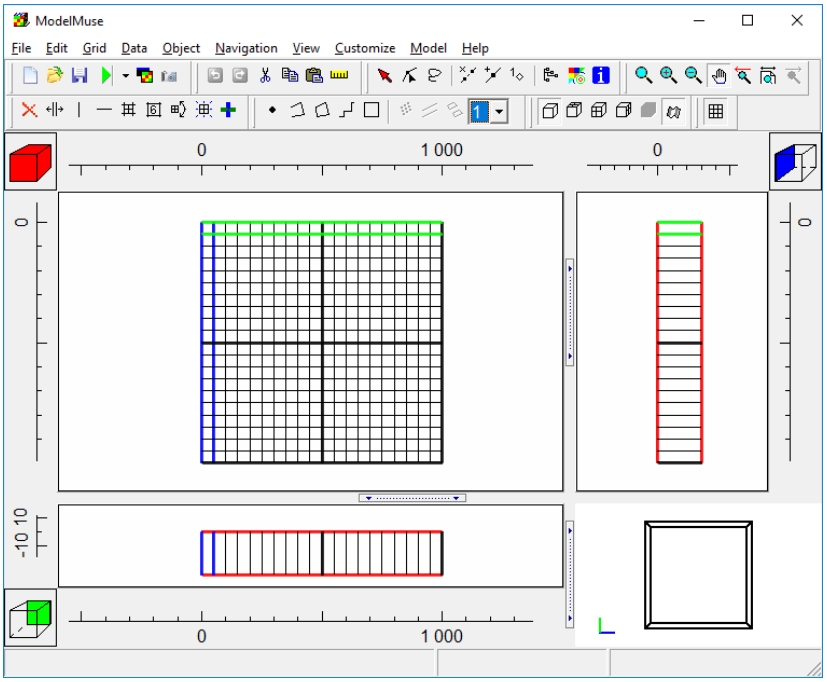
Modflow 6, is a groundwater modelling software, and ModelMuse the graphical interface you will use to run Modflow. Both prograps freely available from the USGS.

- Download ModelMuse from: https://www.usgs.gov/software/modelmuse-graphical-user-interface-groundwater-models
- Install ModelMuse
- Download Modflow 6 from:
- https://www.usgs.gov/software/modflow-6-usgs-modular-hydrologic-model
- When you have downloaded the files extract them to the folder C:/WRDAPP/







Model>MODFLOW Time…

MODFLOW Time

	Length	Max first time step length	Multiplier	Steady State/ Transient
	0	0	0	

Stress period	Starting time	Ending time	Length	Max first time step length	Multiplier	Steady State/ Transient	Drawdown reference	Number of steps (calculated)
1	-1	0	1	1	1	Steady state	☐	1

1 Number of stress periods | seconds (1) | Time unit (ITMUNI) | Delete | Insert

Convert time units | Help | OK | Cancel

MODFLOW Time

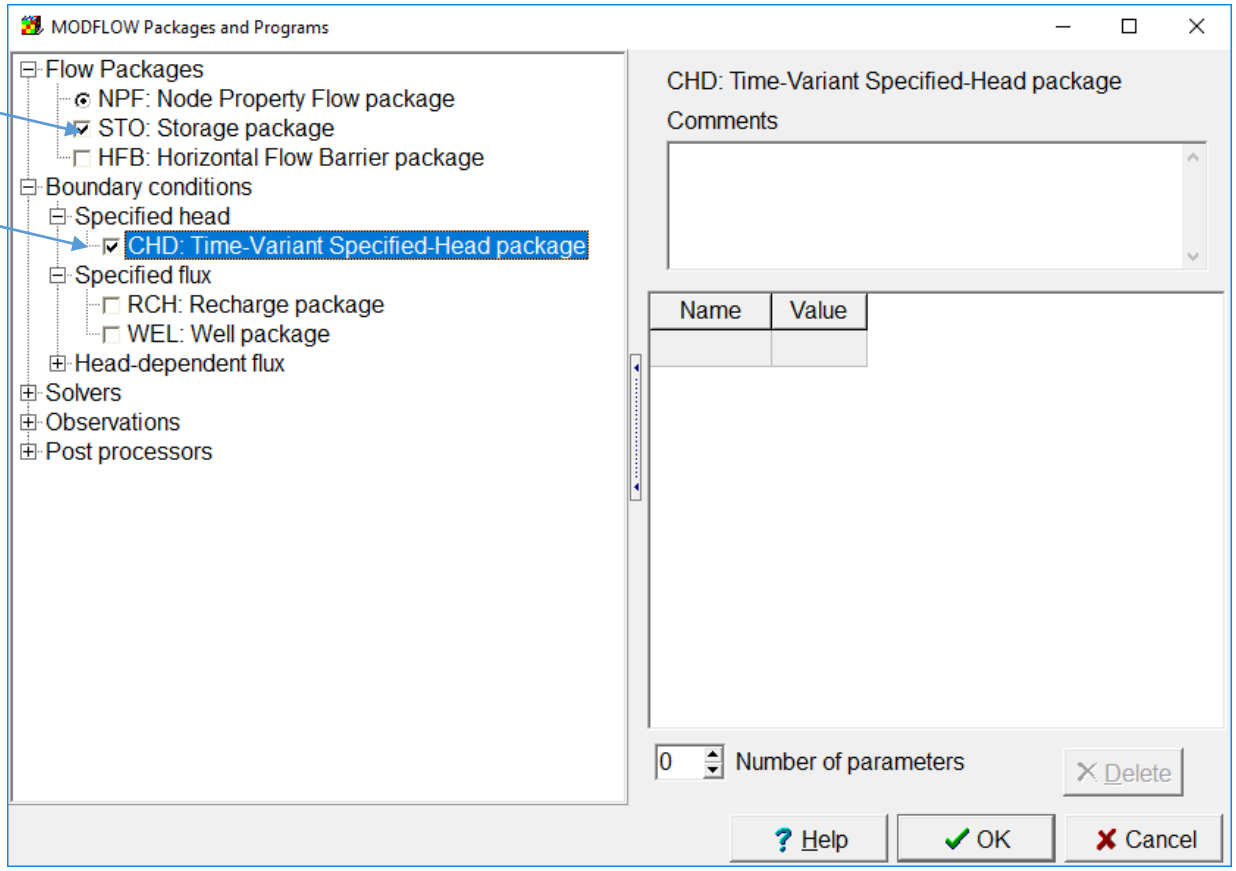
	Length	Max first time step length	Multiplier	Steady State/ Transient
	0	0	0	

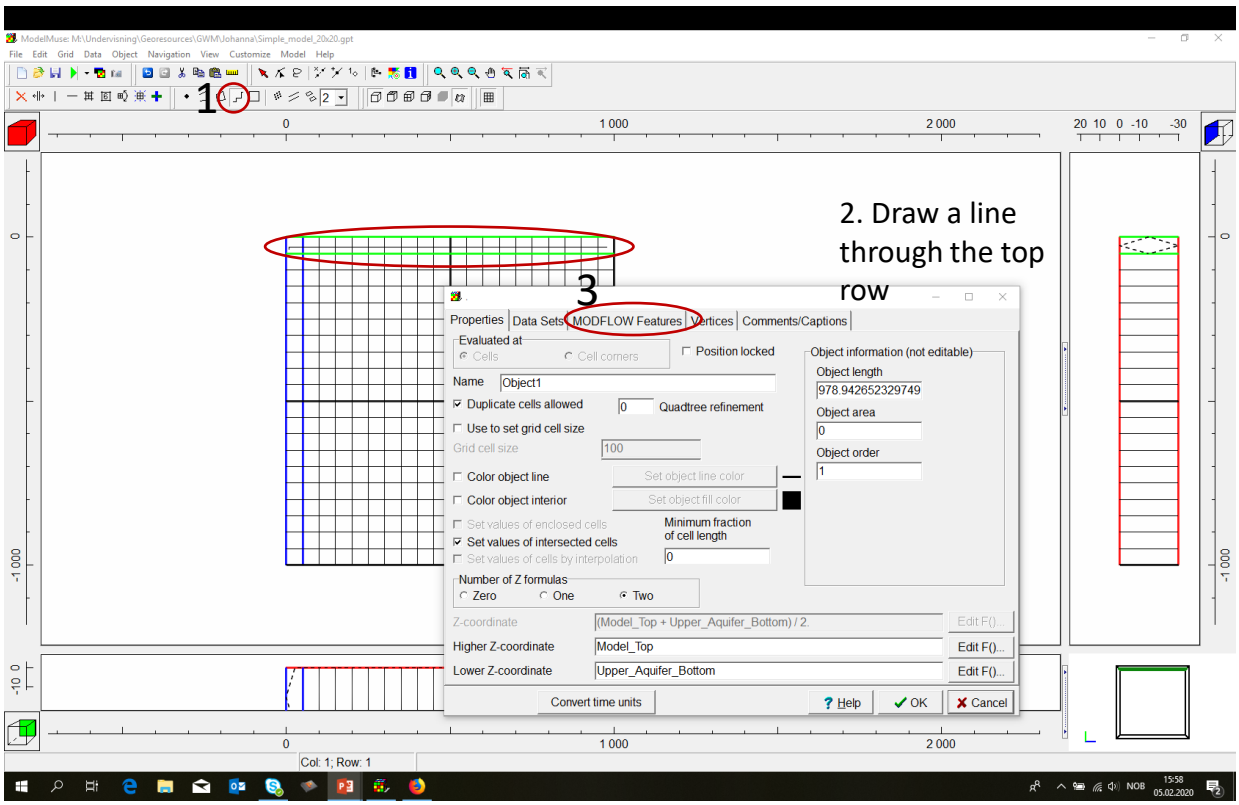
Stress period	Starting time	Ending time	Length	Max first time step length	Multiplier	Steady State/ Transient	Drawdown reference	Number of steps (calculated)
1	-1	0	1	1	1	Steady state	☑	1
2	0	72000	72000	3600	1	Transient	☐	20

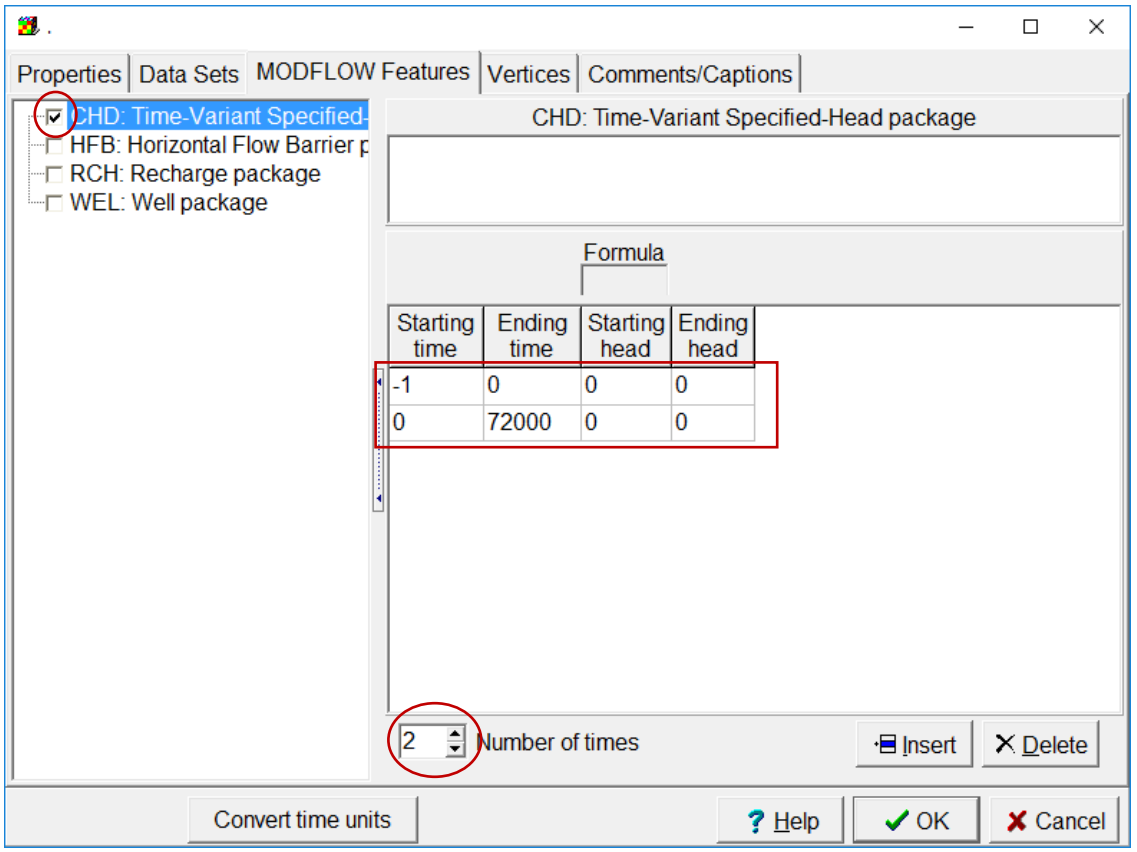
2 Number of stress periods | seconds (1) | Time unit (ITMUNI) | Delete | Insert

Convert time units | Help | OK | Cancel

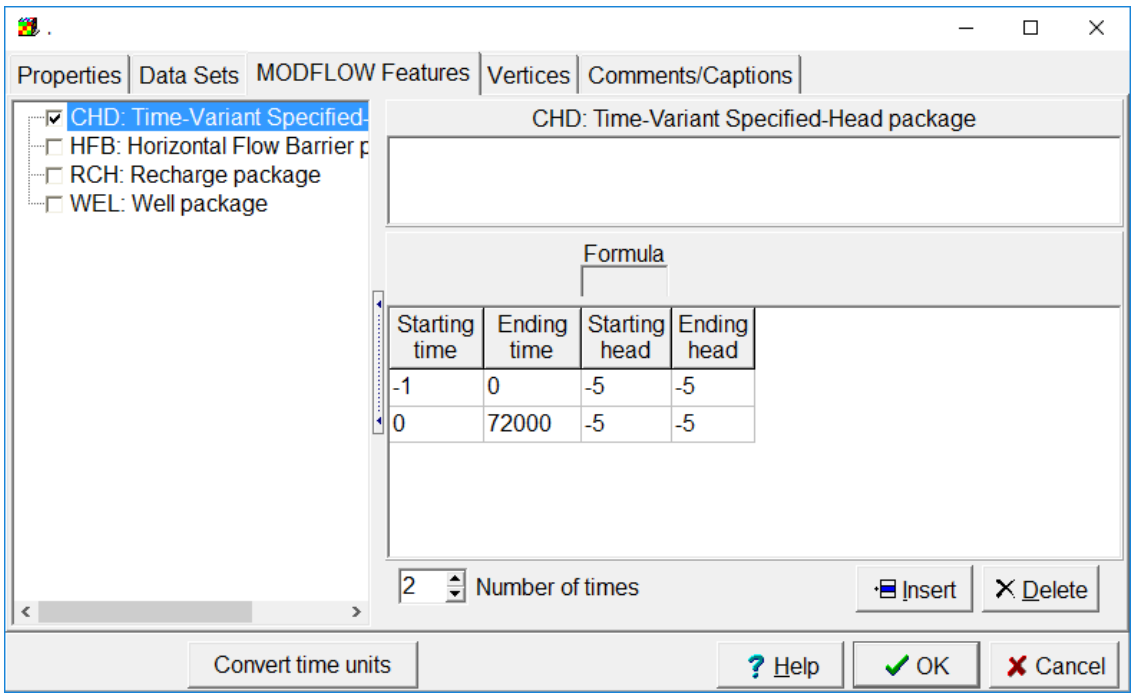
Model>MODFLOW Packages and programs…





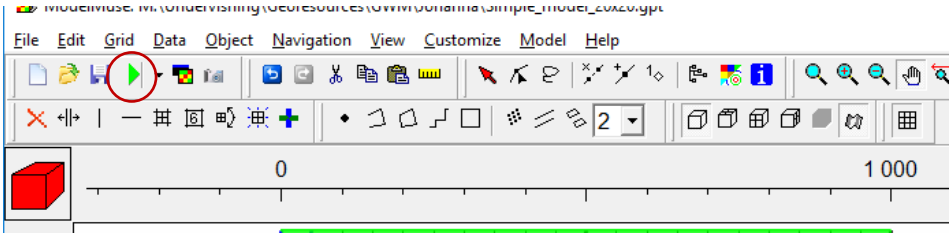


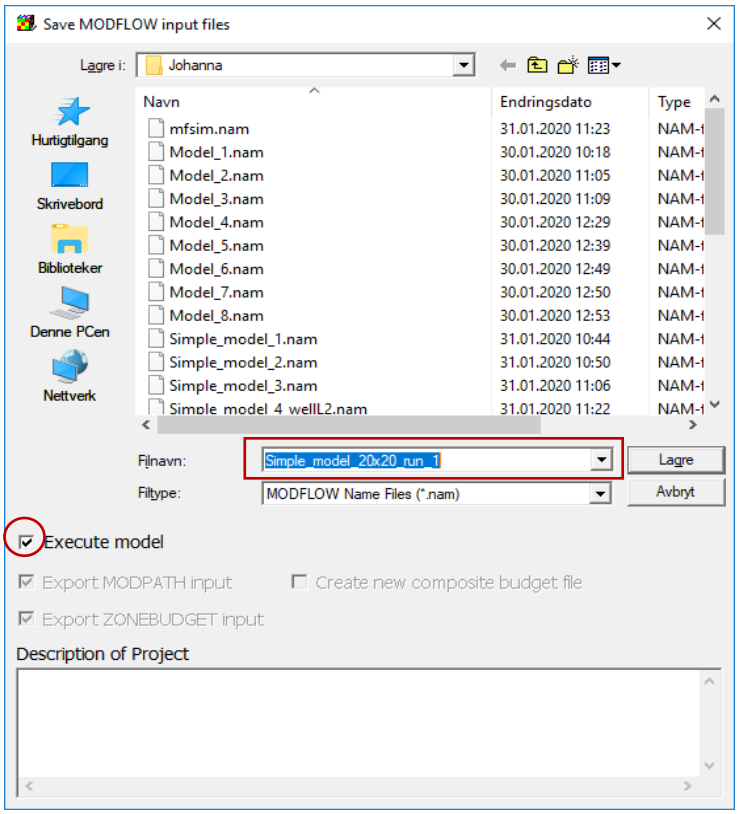
Draw another line, this time through the lowermost row



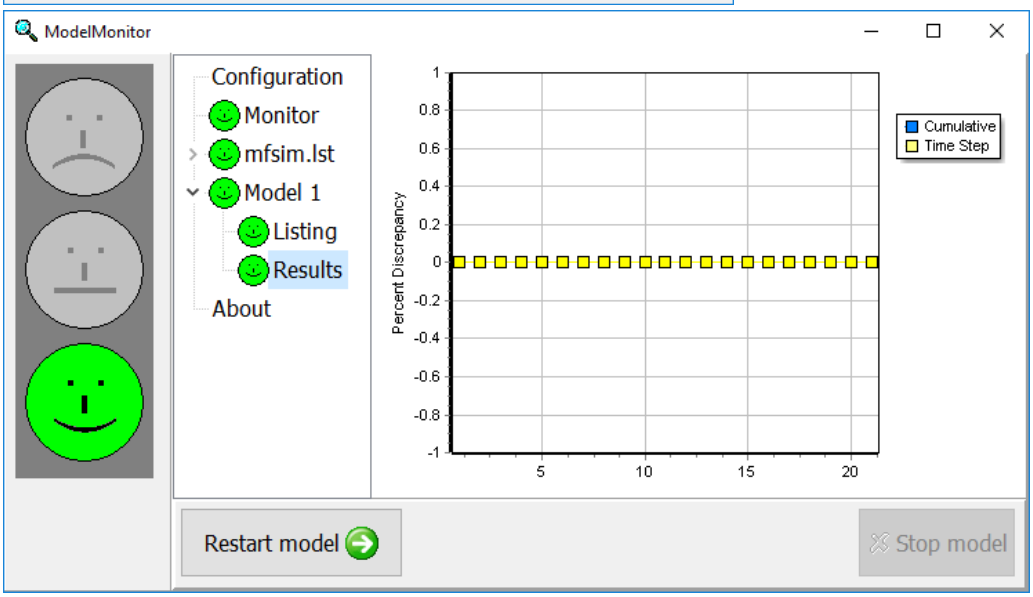
- Save your model.
- **Discuss:** What will happen with the hydraulic head when you run the model?

Run model



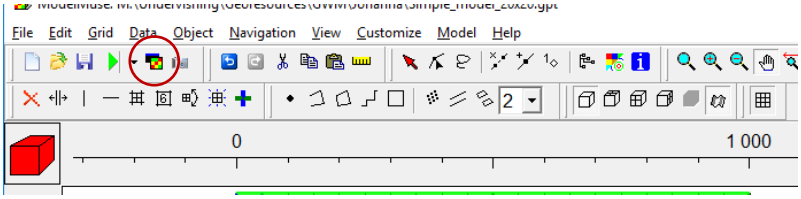


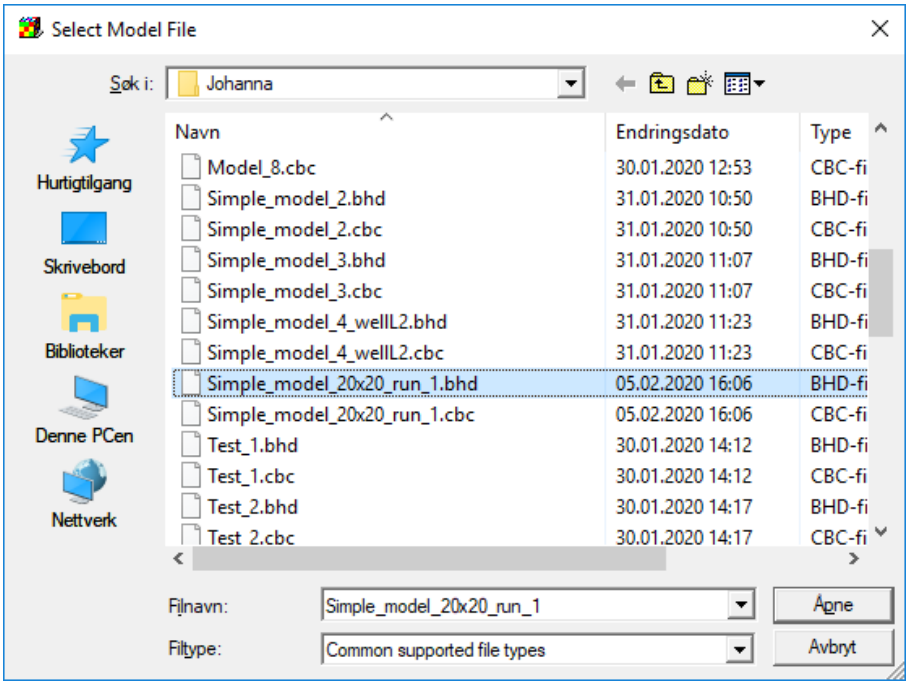
Choose a good name

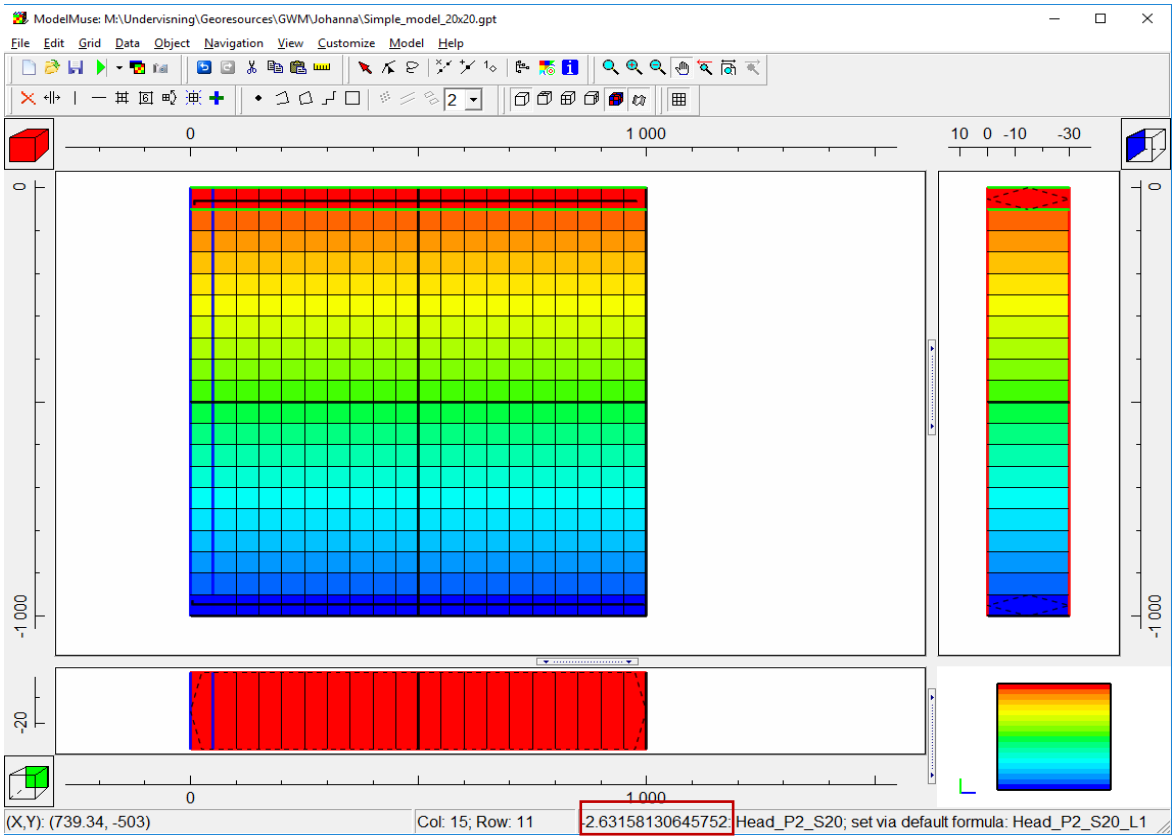


- Successfull run with happy smileys everywhere…
- Close all Model Muse windows apart from the main one

Load the results





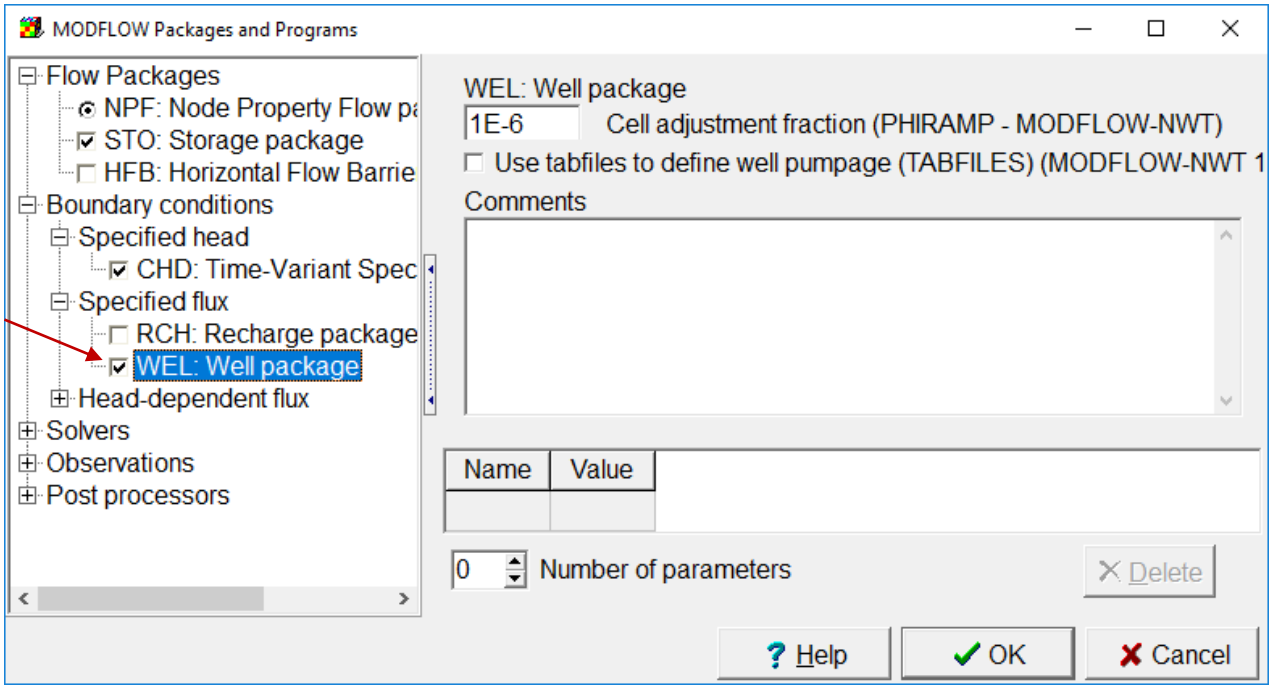


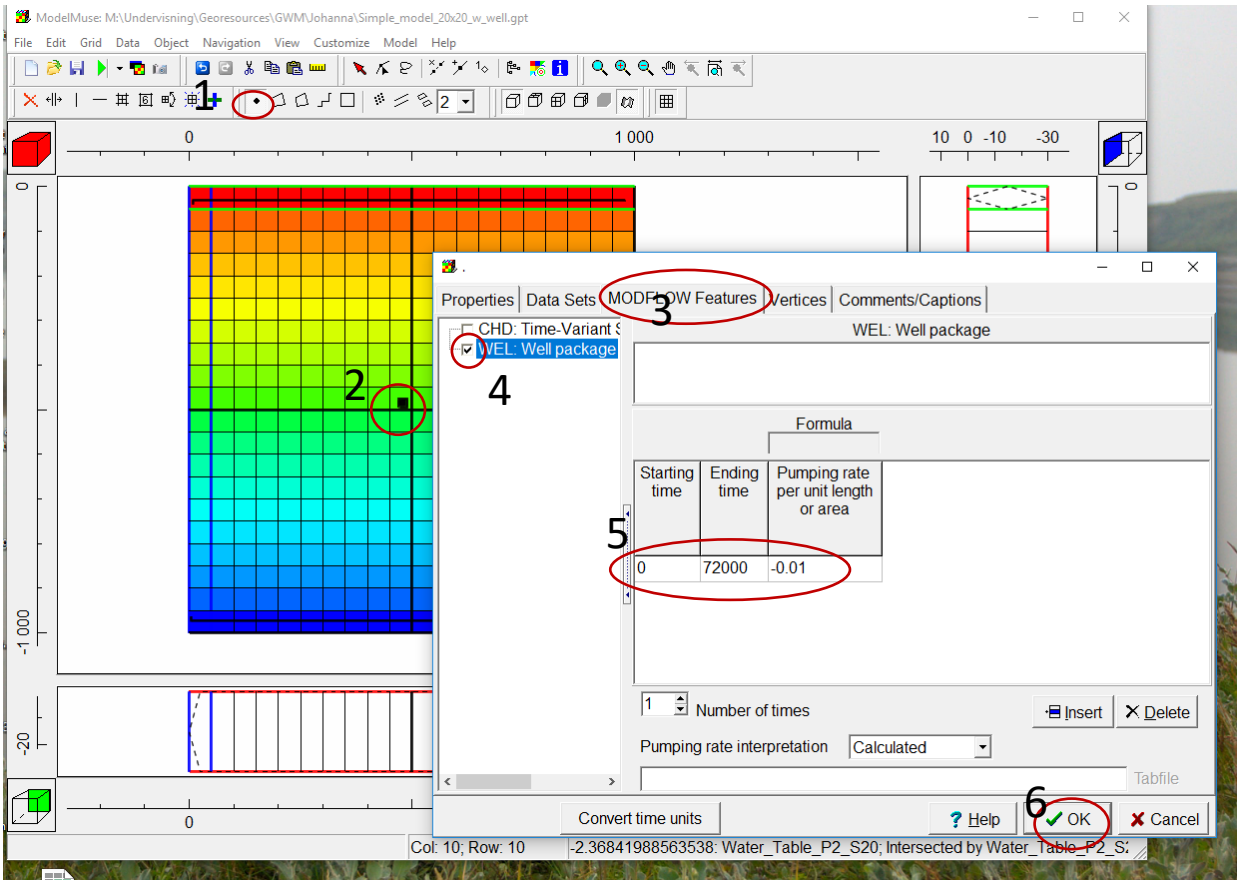
The colours indicate the altitude of the hydraulic head of the layer (red higher, blue lower). Move the cursor over the grid to read the altitudes.

Discuss: How does the groundwater flow in the model?

Time to add a well

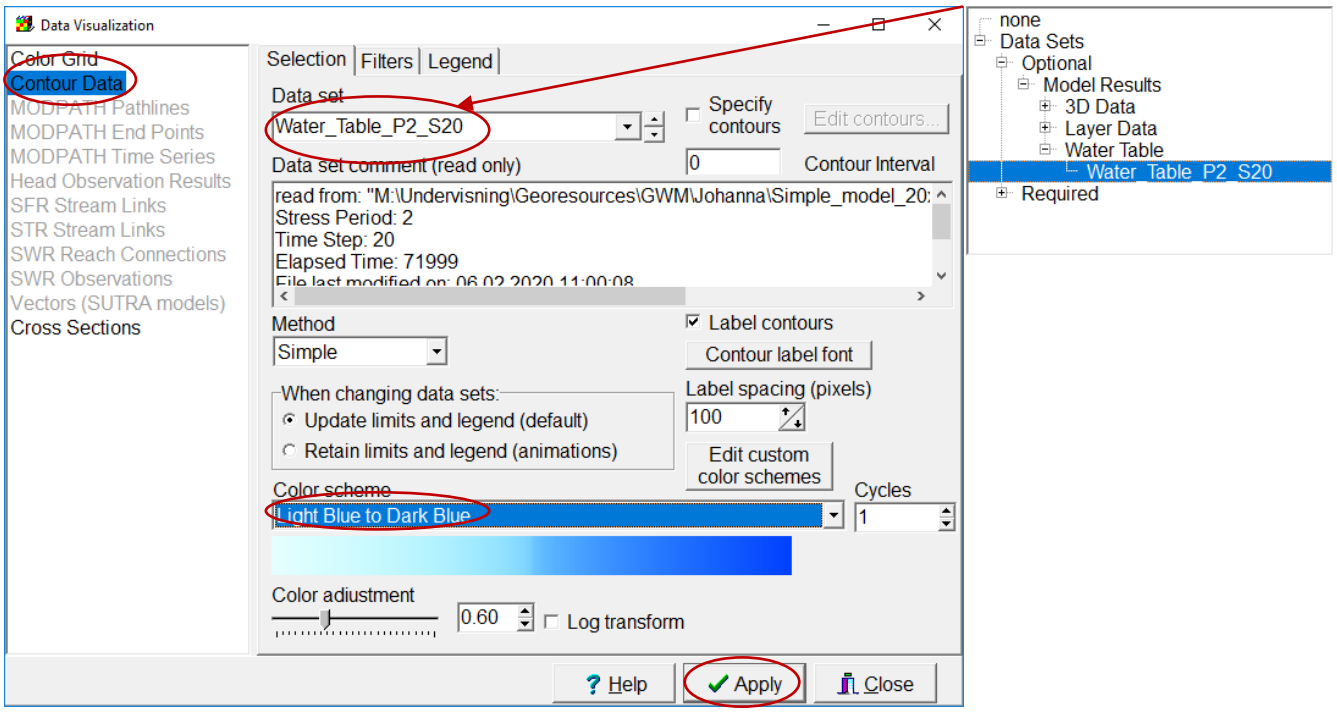
Model>MODFLOW Packages and programs…

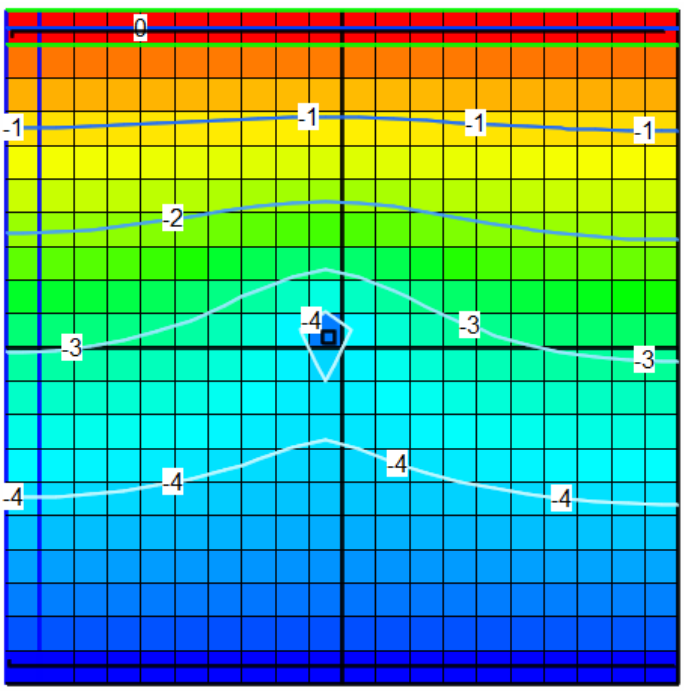




- Run the model again. Save it under a new name.
- Load the data
- **Discuss:**
  - How did the water table change when you added the well?
  - How will that change the groundwater flow?

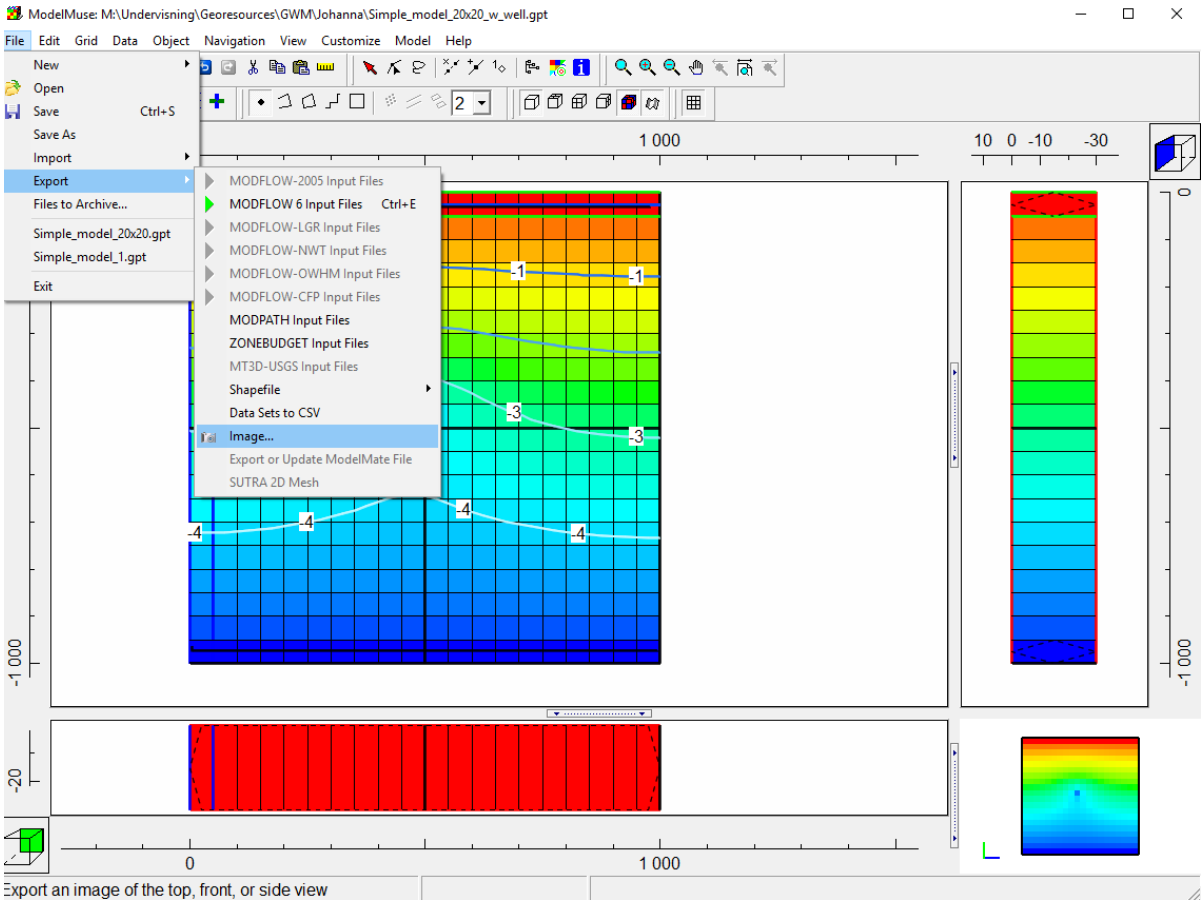
Contour lines can make it easier to see how the groundwater would flow.

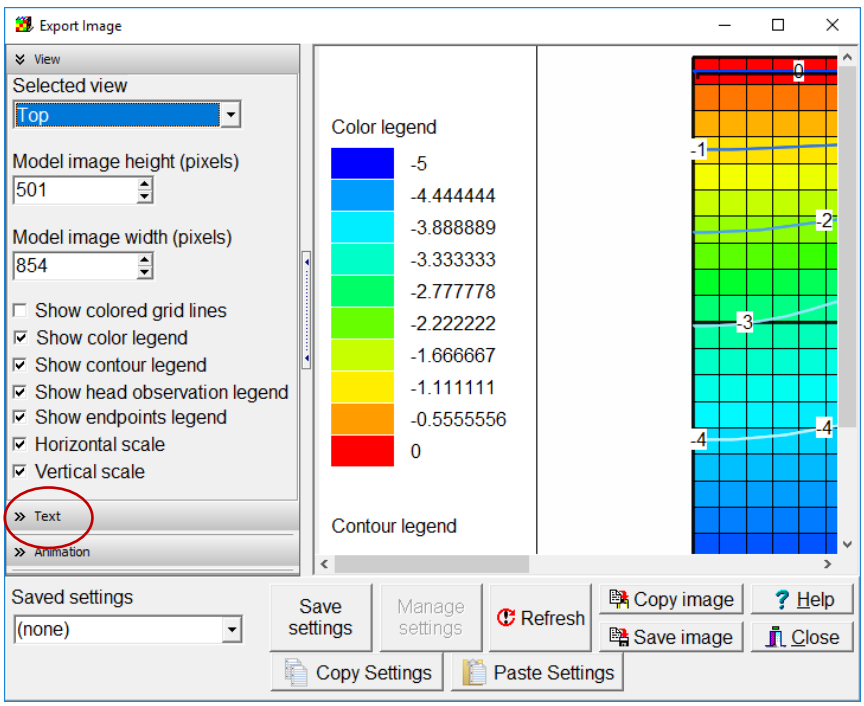


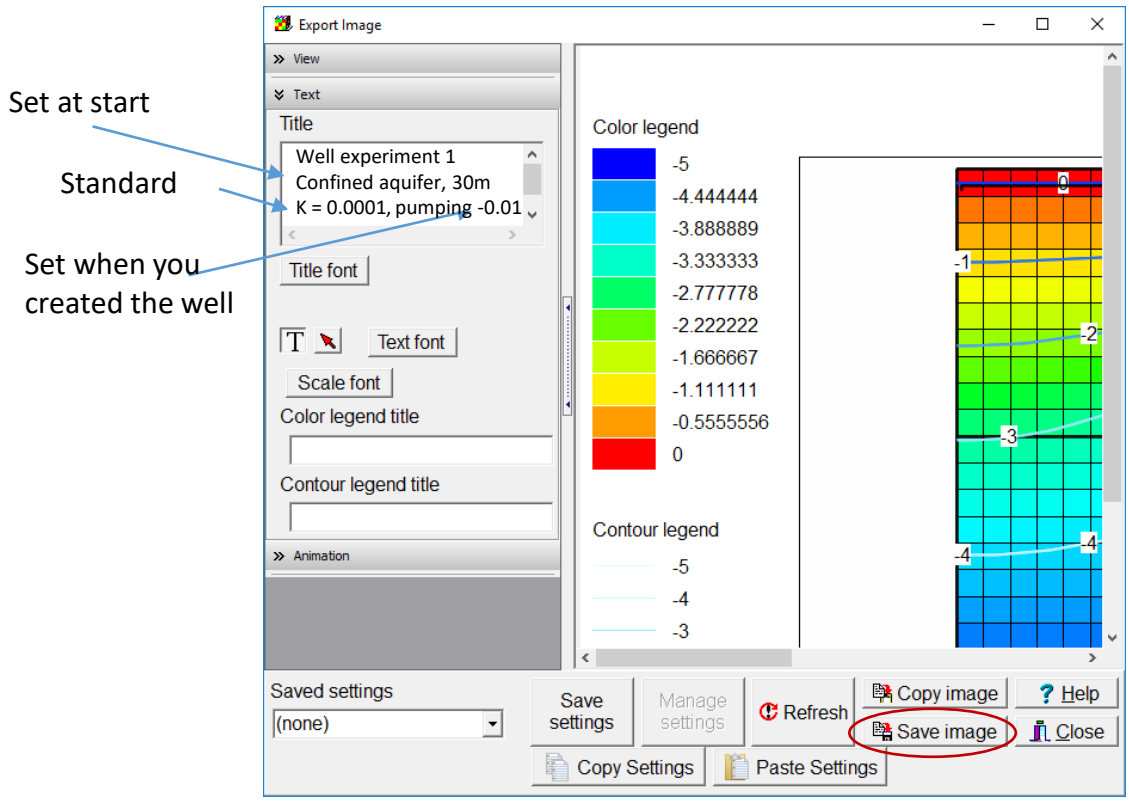


Save your model

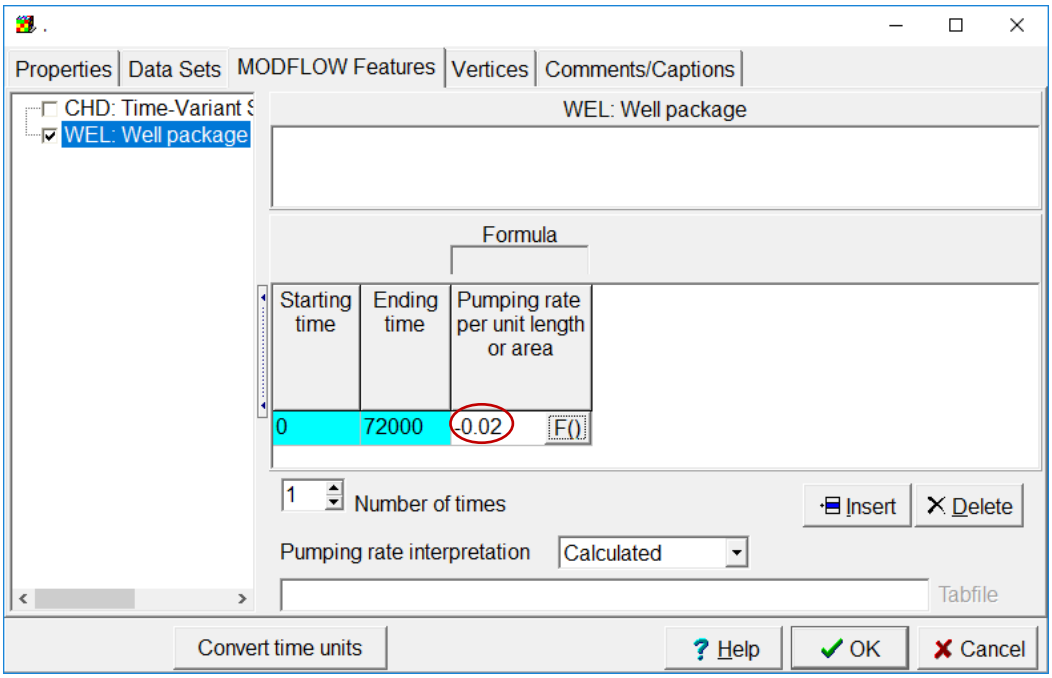
Export your results





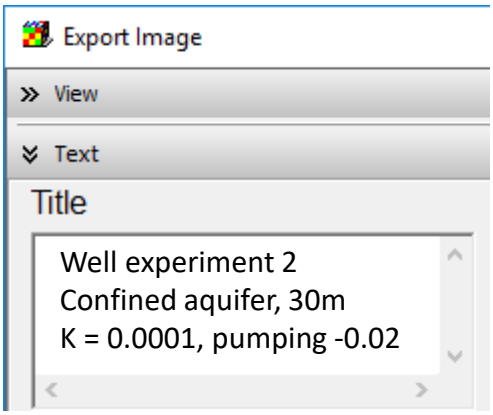


- **Discuss:** What would happen with the groundwater flow if the pumping doubled? Make a prediction.
- Save the model in a new file named e.g. Well_experiment_2.gpt
- Use to red arrow and double-click on your well to get its properties.
    - Under MODFLOW Features change the Pumping rate to -0.02

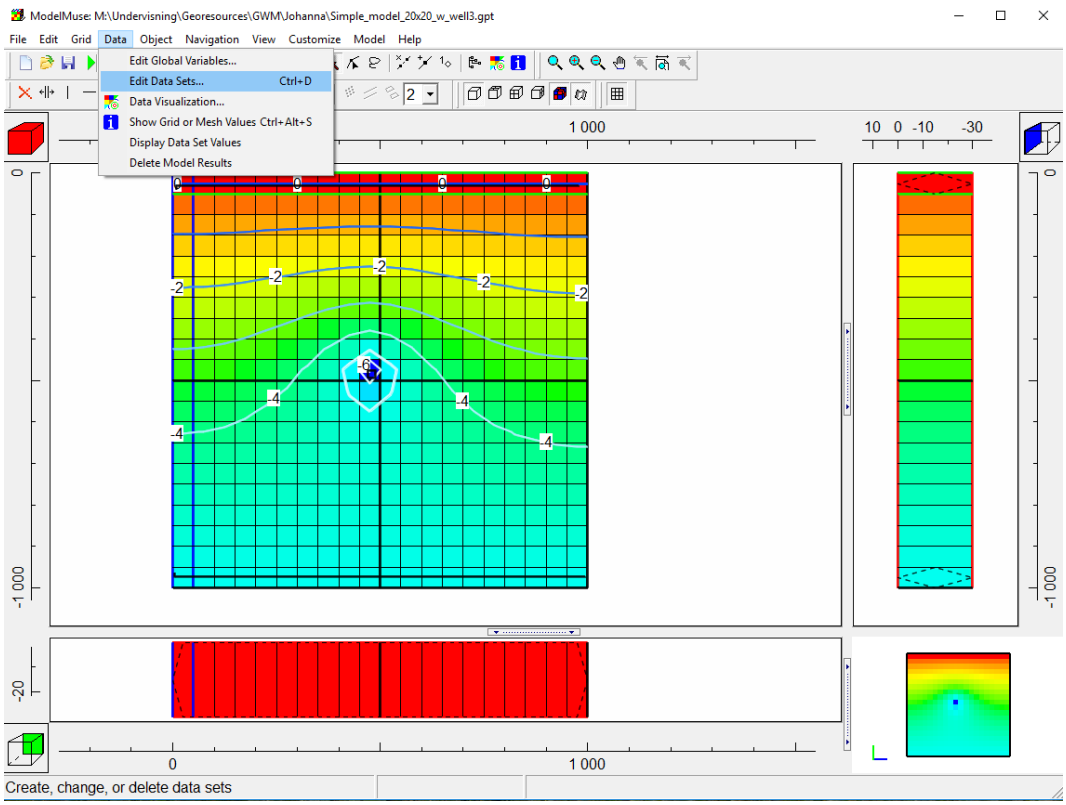


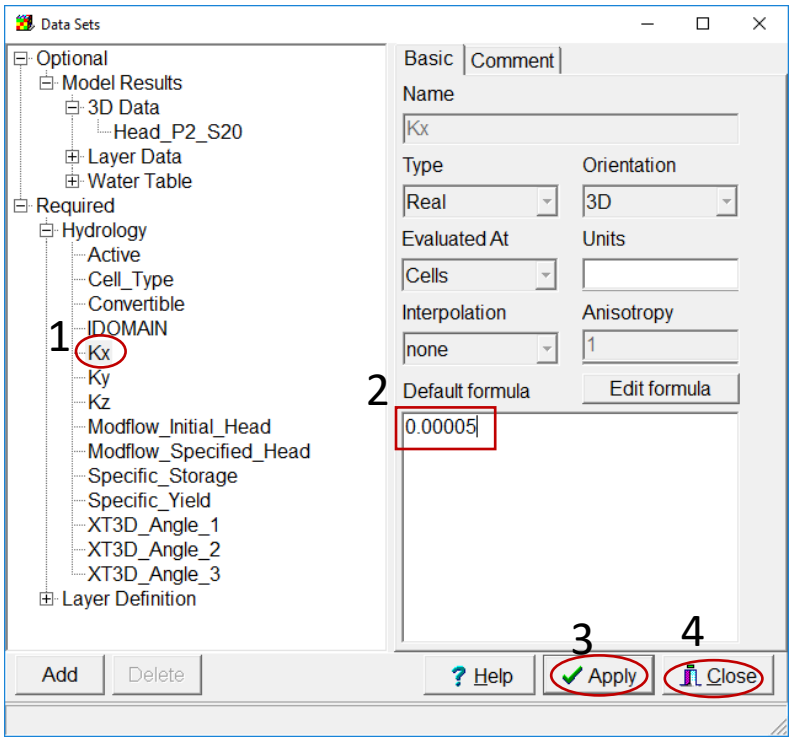
- Run the model
- Load the data.
- Add contours.
- **Discuss:** Compare the results to your prediction.

- Export the result as an image. In the Title text box write:



Next we'll try what happens if we change the aquifer properties…





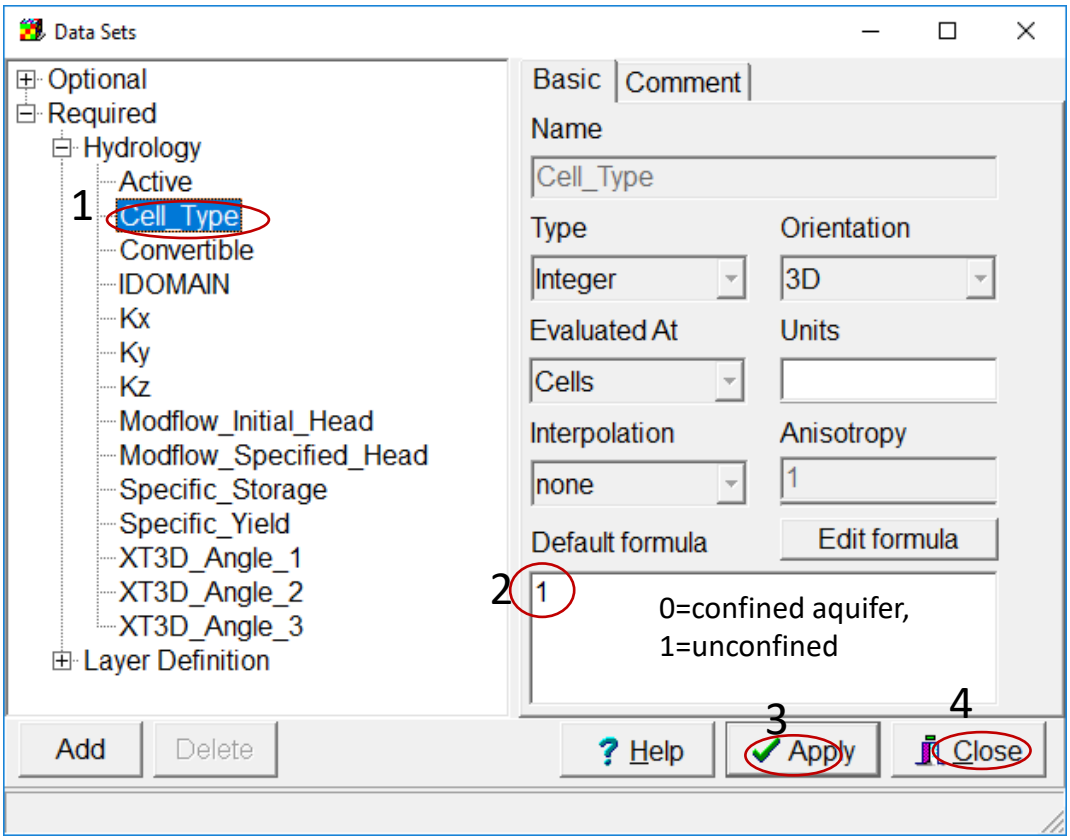
Test using 0.00005, that is half the original level for Kx.
As a standard Kx=Ky=10*Kz so we don't have to change Ky and Kz (but we could).

Discuss: Make a prediction for what will happen to the hydraulic head if the pumping remains the same as in the previous model.

- Run the model
- Load the data.
- Add contours.
- **Discuss**. Compare the results to your prediction.
- Export it as an image file
  Label it:
  Well experiment 3
  Confined aquifer, 30 m
  K=0.00005, pumping -0.02

Finally we will test what would happen in an unconfined aquifer.

- **Discuss:** Make a prediction (all other variables remain as in the previous experiment)
- Data>Edit data sets



- Run the model
- Load the data.
- Add contours.
- **Discuss:** Compare the results to your prediction.
- Export it as an image file
    Label it:
    Well experiment 4
    Unconfined aquifer, 30 m
    K=0.00005, pumping -0.02
- Save your model.

- **Discuss:** Compare the results from your four experiments. What happens when you change the pumping rate or the K-value? What causes the difference you see between the confined and the unconfined aquifer?
- If you have time you may run additional experiments which you decide on yourself.