Two Dimensional flow in an unconfined aquifer

December 31, 2016

In this example, we will create a model of a two dimensional groundwater flow system in an unconfined aquifer. The groundwater system is composed on three no-flow boundary conditions, one fixed head boundary, and two wells. The aquifer has a depth of 11m, and a hydraulic conductivity of 1m/day, a porosity of 0.35 and a specific yield of $S_y = 0.1$. Figure 1 shows a representation of the modeled system.

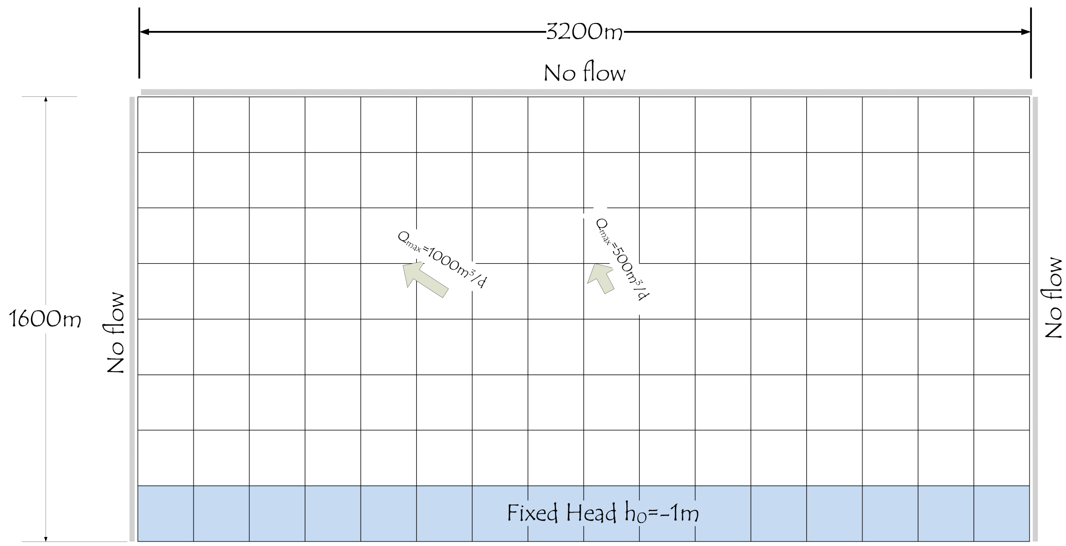

Figure 1: The schematic of he 2-D unconfined aquifer system

Storage blocks will be used to create the model because they allow partially saturated elements, consistent with an unconfined aquifer.

Constant pumping rates

- start GIFMod
- **Create a single Storage block:**

  From the top ribbon click on the Darcy icon . Set the following properties:

  - Bottom area: *40000*m^2.
  - Initial moisture content: *0.1* (results in a specific yield of 0.1)
  - Saturated moisture content: *0.1*
  - Saturated hydraulic conductivity: *1m/day*

- Precipitation: *Yes* (This allows introducing recharge using the precipitation feature.)
- Storage coefficient: $0.0001m^{-1}$ (only becomes effective if a block's moisture content exceeds the saturation moisture content)
- Bottom elevation: *-11m* (this sets the datum on ground surface.)
- Initial water depth: *10m*
- Depth: *11m*
- Width: *200m*
- Length: *200m*
- Dispersivity: *0.05m* (This value is not used in hydraulic simulation, but it will be used when a contaminant transport component is added to the model.)

Leave the rest of the properties unchanged. Default values will be used.

- **Create an array of blocks:**
In this step we create an array of the Darcy block created in the previous step. The array will be composed of 8 rows and 16 columns.
  - Right-click on the Darcy block created in the previous step and choose **Make array of blocks** from the drop-down menu.
  - Choose the **Horizontal 2D array** option and enter the "16" in the text box labeled **Number of columns** and "8" in the text box labeled **Number of rows**.
  - For the **Horizontal distance between cell grids**, enter 200m.
  - For the **Vertical distance between cell grids**, enter 200m.
  - Click on **Ok** button.

  Once you have created the array, your screen should look like Figure 2.

- **Imposition the fixed-head boundary condition:** To impose the fixed head boundary condition at $h_0 = -1m$ select the storage blocks on the bottom row.
  - Select the Storage block labeled "Storage(113)" and type "-1" in the property **Head-storage relationship**.

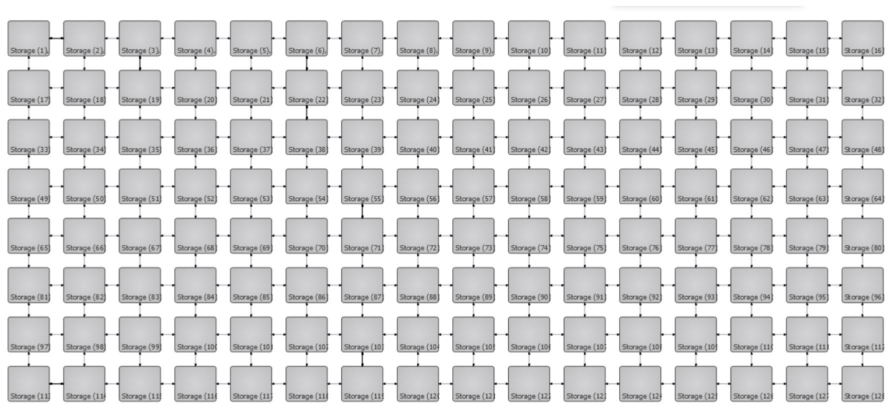

Figure 2: 2-D unconfined aquifer model representation in GIFMod

- Repeat the previous step for all block in the lowest row (Storage(114)-Storage(128)).

- **Introducing the pumping wells:**

  At the time we consider a constant pumping from storage block *Storage(54)* at $1000m^3/day$ and storage block *Storage(57)* at $500m^3/day$ over a 1000days period. The inflow time-series files should look like Figure 3. Create the files and save them respectively as "pumping1000.txt" and "pumping500.txt". Select the block labeled *Storage(54)* and from the properties window find the property called **Inflow time series** and choose *pumping1000.txt*. Repeat the previous task for *Storage(57)* block and select *pumping500.txt*.

- **Setting the duration of the simulation:**
  The duration of the simulation is from day zero to day 1000. From the **Project Explorer** select **Setting→Project settings**. From the property window fine right-click in the label **Simulation end time** and click on **Input Number**. Enter 1000 in the input box that appear.

- Save the project.

- **Running the model:** The model is now ready for running. From the left hand ribbon click on the run button  and wait until the simulation ends.

- **Inspecting the results:**

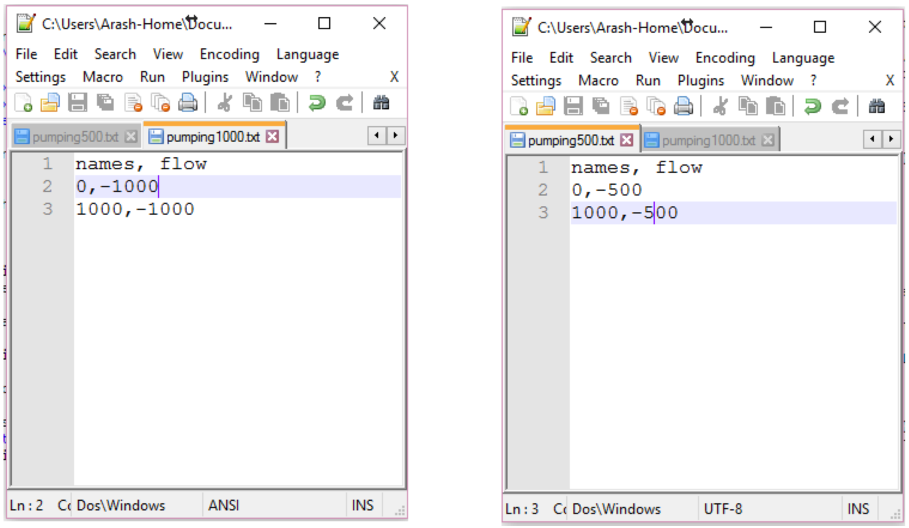

Figure 3: Pumping time-series files

- Right-click on a block of your choice and select **Plot Hydraulic Results→Plot Storage** from the drop-down menu that appears. You may copy and paste the results on one graph to another one for comparison. For example figure 4 shows the storage in blocks *Storage(54)* to *Storage(57)*. As it can be seen the pumping rate leads to a near depletion of water in the block where pumping takes place.
- Right-click on connectors of your choice and select **Velocity** from the drop-down menu. Figure 5 shows the flow rate in connectors connecting *Storage(54)* to *Storage(57)*. This shows the Darcy flux in the connectors.

Revising the example: recovery as a result of reduced pumping after 200 days

Here we are going to modify the previous example by reducing the pumping rate by a factor of five after 200days.

- Make a copy of the pumping files and modify them as shown in figure 6. Save the newly created pumping files with a new names.

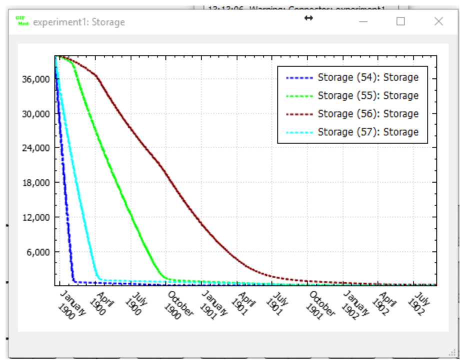

Figure 4: Storage variation in select blocks

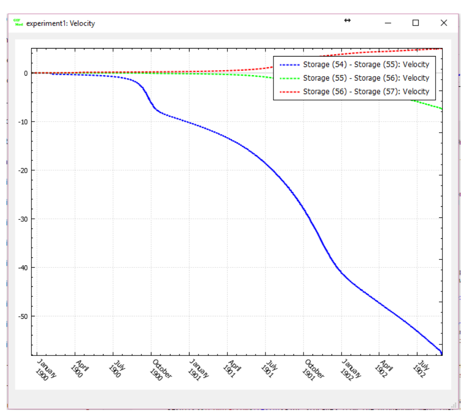

Figure 5: Darcy flux in select blocks

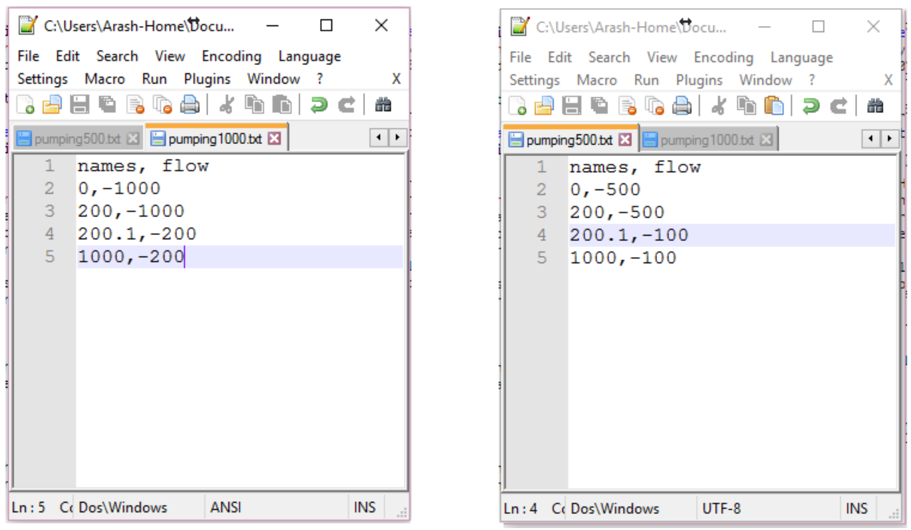

Figure 6: Revised pumping time-series files

- Select the revised inflow time-series files as **Inflow time series** for blocks *Storage(54)* and *Storage (57)* respectively.
- Rerun the program.
- Select desired blocks and connectors and check the new variation of state variables over time.