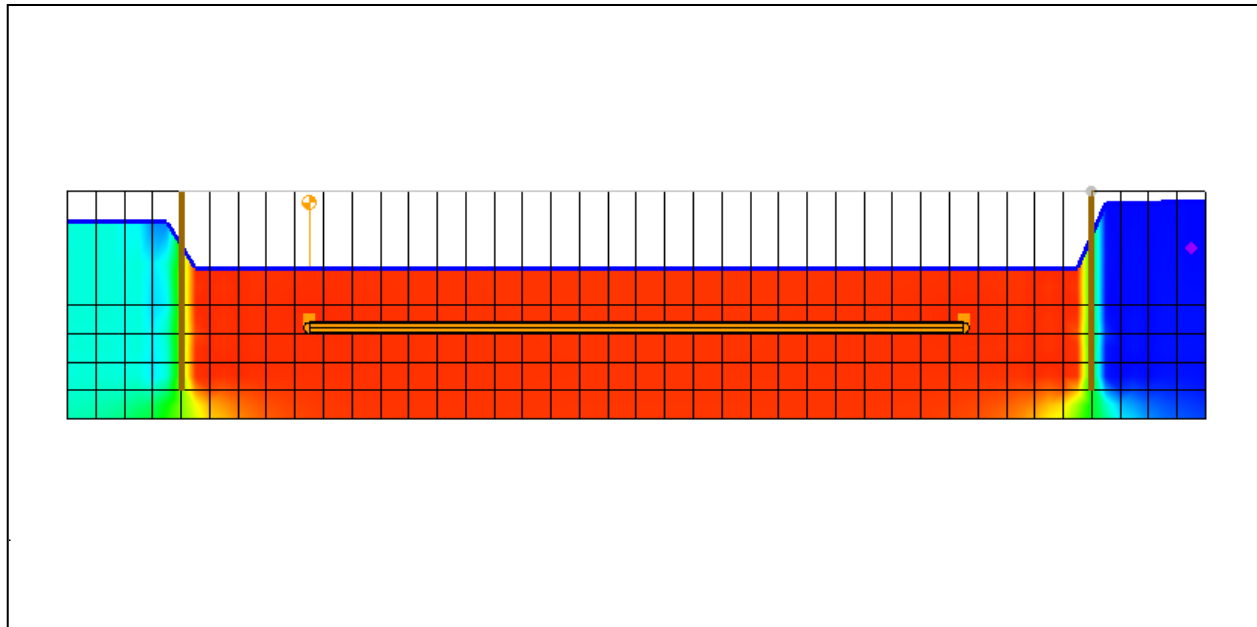


GMS 10.0 Tutorial

MODFLOW – Non Vertical Wells and Pump Curves

Use non vertical wells and pump performance curves in MNW2



Objectives

Learn how to use the non vertical wells and pump capacity options from the MNW2 package in GMS.

Prerequisite Tutorials

- None

Required Components

- Map
- Grid
- MODFLOW

Time

- 30-60 minutes



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2 Introduction

This tutorial is divided into two parts. The first part demonstrates using MNW2 horizontal wells for dewatering. The model is a fictitious construction sites. The second part demonstrates using a pump capacity curve in the model.

2.1 Outline

This is what you will do in this tutorial:

1. Import an existing MODFLOW simulation.
2. Run the simulation and examine the results to understand the MNW2 package options.
3. Modify a conceptual model to use MNW2 instead of the WEL package.

3 Description of Problem

The problem to be solved in this tutorial is shown in Figure 1. The model is divided into 5 unconfined layers. The upper layers (layer 1 to 4) are permeable layers with hydraulic

conductivity of 40 ft/day. The lower layer (layer 5) is an impermeable layer with hydraulic conductivity of 0.1 ft/day. A storage coefficient of 0.0001 and specified yield of 0.05 are assigned uniformly to all 5 layers. The 60000-ft² area is divided into 40 rows and 60 columns. Uniform, square cells of 5 ft are used in the model. Specified head values are assigned in layer 1 and are maintained at the same elevations for all the stress periods. The construction site is surrounded by a diaphragm wall to prevent water from infiltrating into the site.

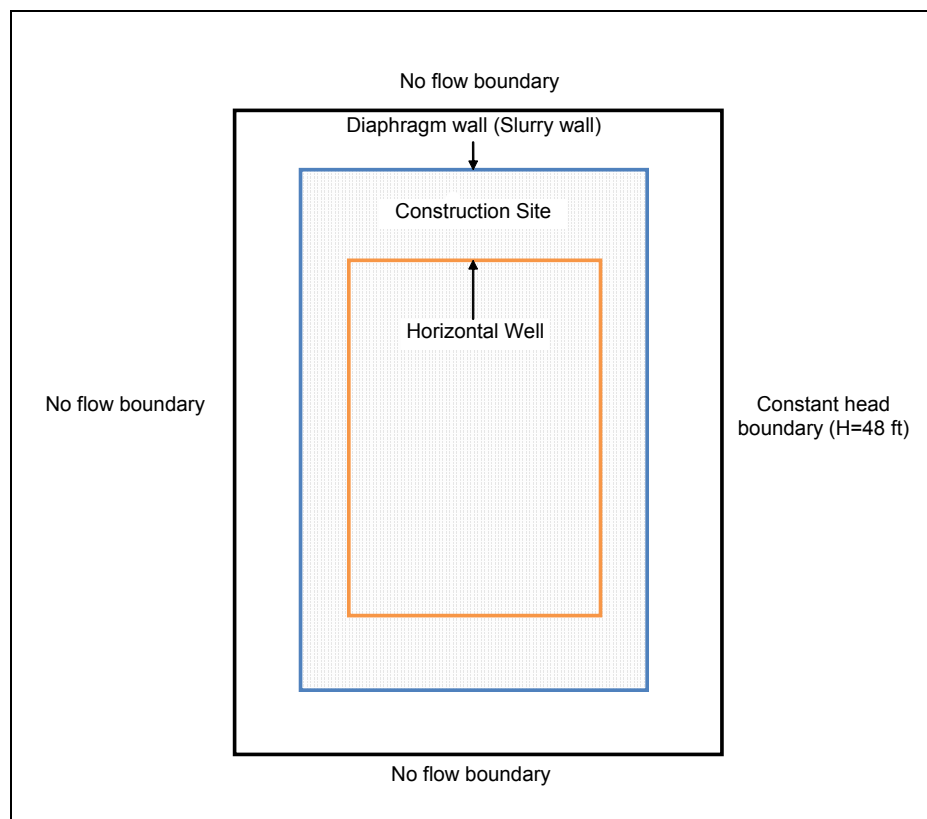


Figure 1. Site model.


4 Getting Started

Let's get started.

1. If necessary, launch GMS. If GMS is already running, select the *File | New* command to ensure that the program settings are restored to their default state.

5 Importing the existing model

We will start with a MODFLOW model that has already been created.

1. Select the  *Open* button (or the *File | Open* menu command).

2. Browse to the \Tutorials\MODFLOW\mnw2adv\ folder.
3. Select the *mnw2.gpr* file and click *Open*.

This imports the model. You should see a grid with specified head boundary (CHD) conditions on the east side.

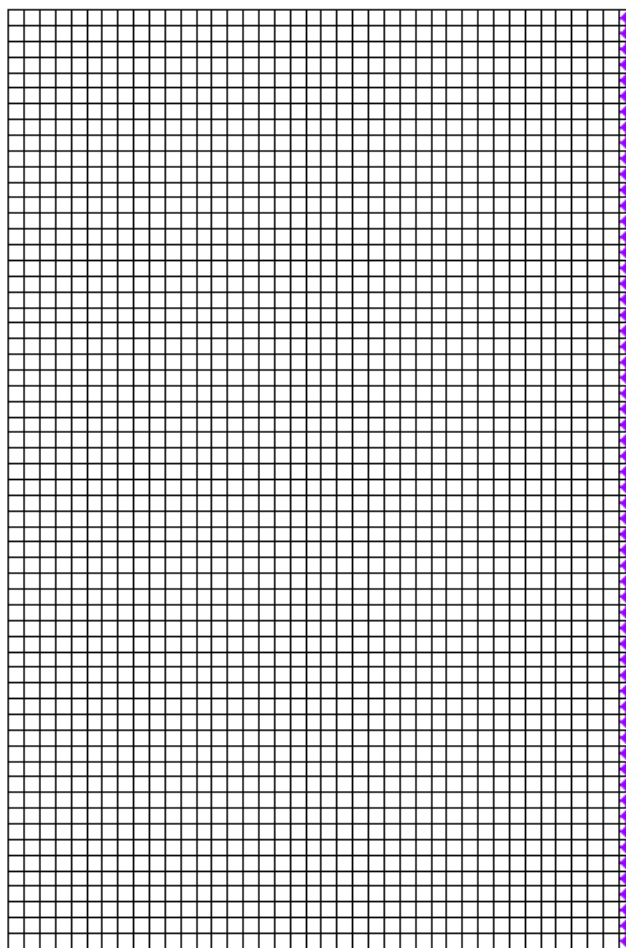


Figure 2. Imported MODFLOW model.



6 Saving the model with a new name

We're ready to start making changes. Let's save the model with a new name.


1. Select the *File | Save As* menu command.
2. Change the project file name to **mnw2_horizontal.gpr**.
3. Save the project by clicking the *Save* button.

7 Examining the diaphragm wall

One of the main purposes of the diaphragm wall is to prevent water from infiltrating into the site. The diaphragm wall can be simulated in GMS by using the Horizontal Flow Barrier (HFB) Package.

1. Uncheck the  3D Grid Data in the Project Explorer.
2. Right-click in the *Project Explorer* and select the *Expand All* command.
3. Double click on the **diaphragm wall** coverage  in the *Project Explorer*.

The default layer range is from layer 1 to layer 4. This will make the diaphragm wall extend through grid layers 1 to 4 when we map to MODFLOW.

4. Select the *OK* button.
5. Choose the *Select Arc* tool .
6. Double click on the arc.

Notice that the arc is assigned with *Type of barrier* and *Hyd. char.* (hydraulic characteristic) of **0.01**.


7. Select the *OK* button.

8 Creating the horizontal well

We'll create a shallow horizontal well system to dewater the site. This can be accomplished using the non vertical well capabilities available in MNW2.






8.1 Creating an MNW2 coverage

First, we will create a new coverage.


1. Right-click on the **Construction Site** conceptual model  and select the *New Coverage* command from the pop-up menu.
2. Change the *Coverage name* to **MNW2**. Change the *Default elevation* to **50**.
3. In the list of *Sources/Sinks/BCs*, turn **on** the *Wells (MNW2)* option.
4. Select the *OK* button.

8.2 Creating the horizontal well

Now we'll create the horizontal well.

1. Select the *Create Point* tool .
2. Click once anywhere in the window with the mouse to create the point.
3. While the new point is selected, type the coordinates (**42.5, 247.5, 50**) in the *X*, *Y* and *Z* edit fields at the top of the GMS window and hit the *Tab* or *Enter* key.
4. Select the *Select Points/Nodes* tool .
5. Select the point you just created by clicking on it.
6. Select *Properties* button .
7. Change the *Name* to **Well_A**.
8. Change the *Type* to *well (MNW2)*.
9. For the pumping rate (*Qdes*), click the down arrow  button and select the **<transient>** option from the drop down list.
10. Now click the  button for the *Qdes* to bring up the *XY Series Editor*.
11. Enter the following time and *Qdes*:

Time	Qdes (ft/day)
0	-9000
5	-9000
5	-3000
30	-3000

12. Select the *OK* button.
13. Uncheck the *Vertical Boreline* option.
14. Click the  button for *Boreline* to bring up the boreline dialog.
15. Enter the following values:

X screen begin (ft)	Y screen begin (ft)	Z screen begin (ft)	X screen end (ft)	Y screen end (ft)	Z screen end (ft)
42.5	247.5	27.0	42.5	247.5	26.0
42.5	247.5	26.0	42.5	48.5	26.0
42.5	48.5	26.0	157.5	48.5	26.0
157.5	48.5	26.0	157.5	247.5	26.0
157.5	247.5	26.0	42.5	247.5	26.0

16. Select the *OK* button.
17. Change the *LOSSTYPE* to **THIEM**.
18. Enter **0.5** for *Rw*.

19. Select the *OK* button.

Your horizontal well should look similar to one shown in the following figure:

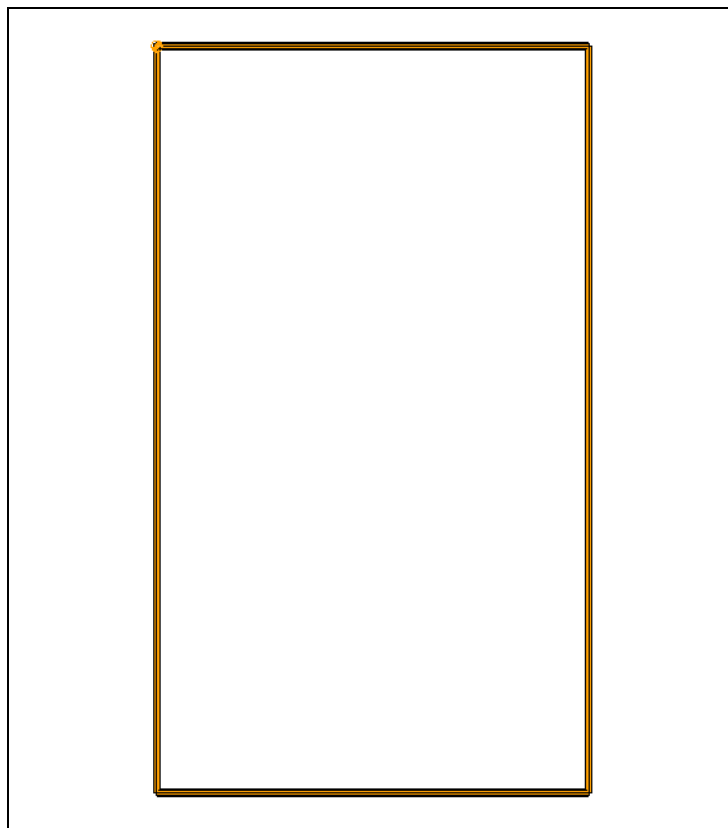









Figure 3. Horizontal well.

9 Converting the Conceptual Model

We are now ready to convert the conceptual model from the feature object-based definition to a grid-based MODFLOW numerical model.

1. Right-click on the *Construction Site* conceptual model  and select the *Map To | MODFLOW / MODPATH* command.
2. Make sure the *All applicable coverages* option is selected and click *OK*.
3. Click on the *Ortho/General Mode* button  to switch to *Ortho Mode*.
4. Turn on the  *3D Grid Data* in the *Project Explorer*.
5. Select the up arrow  in the toolbar to go to layer 2.

Notice that the cells underlying the barrier and wells were all identified and assigned the appropriate sources/sinks.

6. Click on the  *3D Grid Data* folder to switch to the 3D Grid module.
7. Click on the  *Select Cells* tool.
8. Select a grid cell somewhere in the middle of the model.
9. Switch to  *Front View*.

You should see the horizontal barriers extending from layers 1 through 4 on the left and right sides and the horizontal well in layer 2.

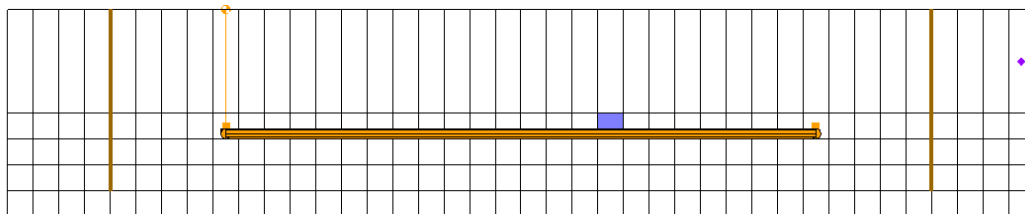


Figure 4. Model in front view.

10 Viewing the MNW2 well

Before running the simulation, we'll look at the well in the MNW2 package data that was created using the conceptual approach.



10.1 Opening the MNW2 Package Dialog


1. Select the *MODFLOW | Optional Packages | MNW2 - Multi-Node Well* command to open the MNW2 Package dialog.
2. Click on the *Wells* button.
3. Click on the spreadsheet row for *WELL_A*.

Notice the nodes for Well-A are listed in the bottom spreadsheet. These nodes are automatically assigned to the appropriate cells based on the conceptual model.

11 Running MODFLOW



Now we are ready to save our changes and run MODFLOW.

1. Select the  *Save* button (or the *File | Save* menu command).
2. Select the  *Run MODFLOW* button.
3. When MODFLOW finishes, select the *Close* button.

4. Select the  *Save* button to save the project with the new solution.

12 Viewing the Water Table

We'll view the solution at different time steps to see the drawdown.

1. Expand the *mnw2_horizontal (MODFLOW)* item  in the *Project Explorer* and select the *Head* data set .
2. Use the *Time Step Window* to cycle through the different time steps of the solution to see how the pumping schedules of the well affect the water level.

Note that the water level keeps decreasing for the first 5 days. After lowering the pumping rate after 5 days, the water level seems to reach a steady state for the site. This is consistent with the pumping schedule we entered. You might wish to adjust the pumping rate to see how it affects the water table.

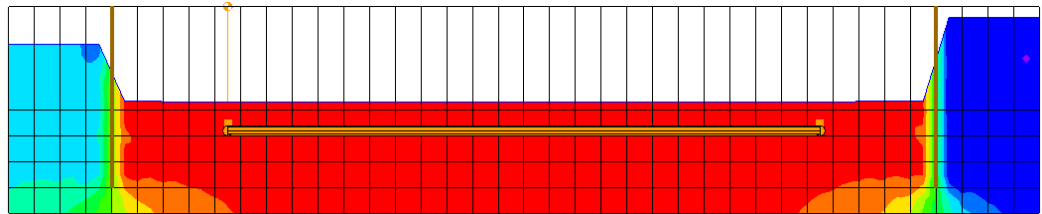


Figure 5. Water table at the end of the simulation.




13 Saving the model with a new name



Now we're going to examine the pump capacity curve option in MNW2. First, let's save the model with a new name.

1. Select the *File | Save As* menu command.
2. Change the project file name to **mnw2_pumpcurve.gpr**.
3. Save the project by clicking the *Save* button.

14 Modifying the existing well

We will apply the pumping curve to the existing well.

1. Select the **MNW2** coverage  in the *Project Explorer*.
2. Select the *Select Points/Nodes* tool .
3. Select the well by clicking on the well .

4. Select *Properties* button .
5. Click **on** the box in the *PUMPCAP* field. You might need to scroll to the right.
6. Enter the value **50.0** for *Hlift*.
7. Scroll to the far right until you see *Pump capacity curve*. Click on the  button.
8. Enter the following data

Yield (ft ³ /d)	Total Dynamic Head (ft)
0.0	15.0
3000.0	14.0
5000.0	13.0
7000.0	10.0
9000.0	6.0
9. Select the *OK* button.
10. Enter **1.0** for the *Pump capacity mult*.
11. Click *OK*.

We turned on the option to use pump capacity in step 5. In step 6, we specified the Hlift value to be 50 ft. Hlift is the reference head (or elevation) corresponding to the discharge point. In our tutorial, the top elevation is at 50 ft. We assumed that the pump is put at the top elevation.

In step 7 and 8, we defined the pump capacity curve. The model will calculate the pumping rate based on these numbers. If the water level is from 50 ft (at top elevation) to 44 ft (top elevation minus 6.0 ft), the pump will withdraw water at 9000 ft³/d. The model will interpolate the pumping rate linearly for water levels between 44 ft to 35 ft (top elevation – 15.0 ft) based on the provided numbers. If the water level falls below 35 ft, the model will shut down the well.

In step 10, we specified **1.0** for the pump capacity multiplication. This means that the head-capacity relations defined in step 7 and 8 are used. If we specify any value less than or equal to 0, the head-capacity relations will be ignored for that particular stress period. We can also specify any other positive value such as 2.0. The model will adjust the withdrawal rate from the head-capacity curve by multiplying the withdrawal rate by the pump capacity multiplication factor. For this example, we want to use the exact head-capacity curve for all the stress periods. Therefore, we specified a constant value of **1.0** for the pump capacity multiplication factor.

15 Converting the Conceptual Model




We are now ready to convert our changes to MODFLOW.

1. Right-click on the **MNW2** coverage  and select the *Map To | MODFLOW / MODPATH* command.

This should update the well.



16 Running MODFLOW

Now we are ready to save our changes and run MODFLOW.

1. Select the  *Save* button (or the *File | Save* menu command).
2. Select the  *Run MODFLOW* button.
3. When MODFLOW finishes, select the *Close* button.
4. Select the  *Save* button to save the project with the new solution.

17 Viewing the Water Table

We are now ready to examine the new result

1. Expand the *mnw2_pumpcurve (MODFLOW)* item  in the *Project Explorer* and select the *Head* data set .
2. Use the *Time Steps* window to cycle through the different time steps of the solution.

Notice that the pump does not always perform at full capacity and the water level at the end of 5 days is much higher compared to the previous scenario. You might wish to use the flow budget to see the change in pumping rate over time.

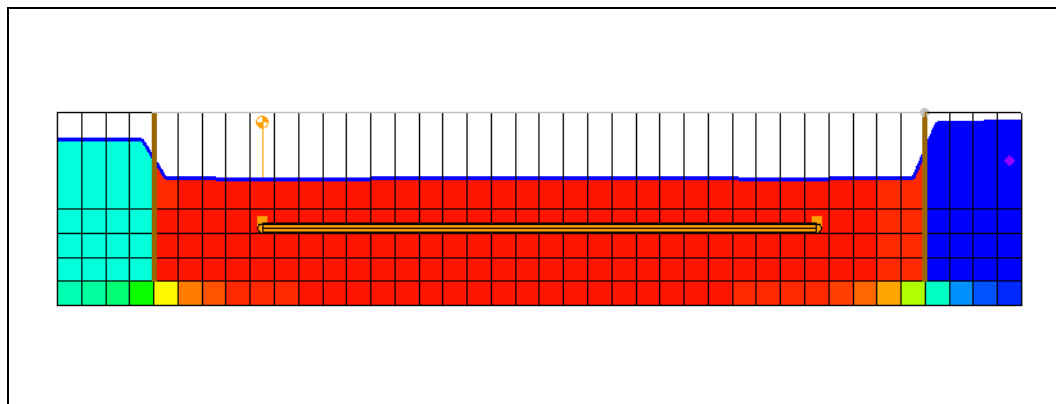


Figure 6. Water table after the first 5 days.

18 Conclusion

This concludes the tutorial. Here are the things that you should have learned in this tutorial:

- GMS supports the MNW2 package.
- You can specify non-vertical wells using MNW2.
- You can specify head-capacity pumping curves in MNW2.
- MNW2 wells can be created in the conceptual model and mapped to the grid.