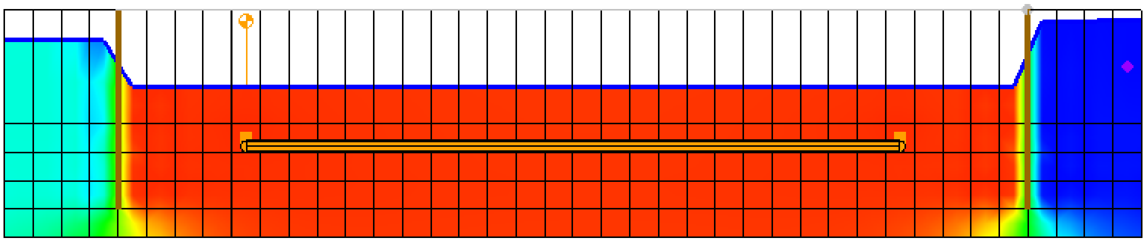
v. 10.0

GMS 10.0 Tutorial

MODFLOW – Nonvertical Wells and Pump Curves

Use nonvertical wells and pump performance curves in MNW2



Objectives

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

Prerequisite Tutorials

- MODFLOW – MNW2 Package

Required Components

- Map Module
- Grid Module
- MODFLOW

Time

- 20-40 minutes

1 Introduction

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

1.1 Outline

Here are the steps 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.

2 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-ft^2 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.

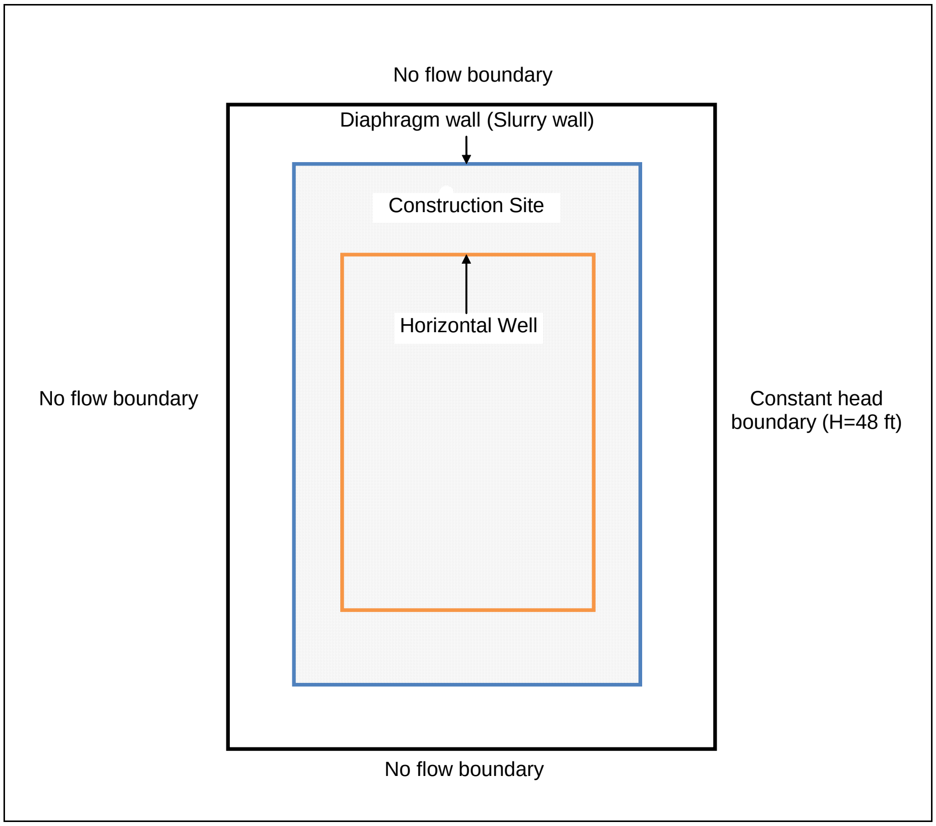


Figure 1 Site model

3 Getting Started

Do the following to get started:

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

4 Importing the Existing Model

The user 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.

4. Click **Open**.

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

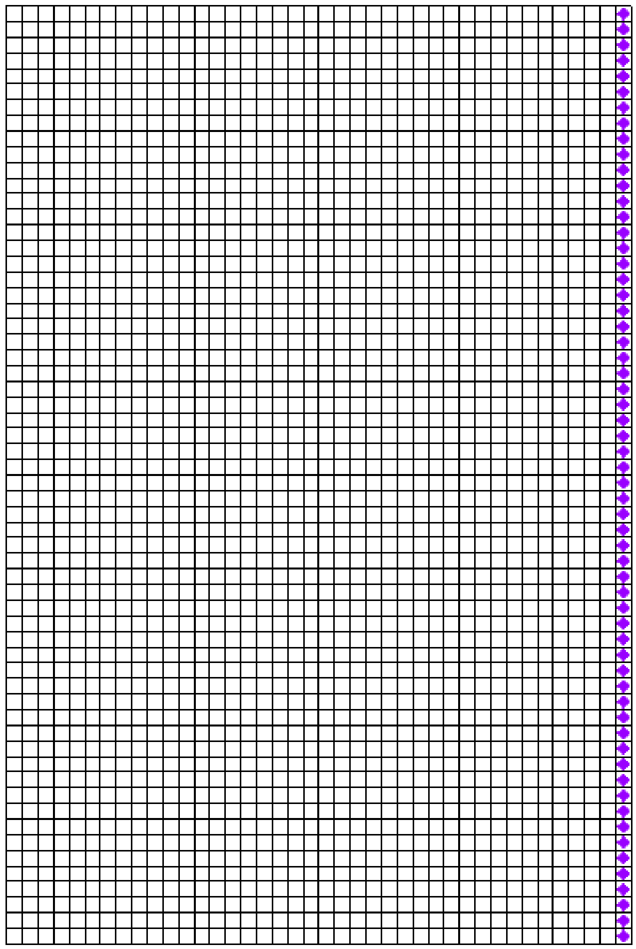


Figure 2 Imported MODFLOW model

5 Saving the Model with a New Name

Now it is possible to start making changes. First, 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.

6 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" folder 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 the user maps to MODFLOW.

4. Select the **OK** button.
5. Select the "3D Grid Data" folder to make it active again.
6. Choose the **Select Arc** tool.
7. Double-click on the arc.

This brings up the *Attribute Table* dialog. Notice that the arc is assigned with *Type* of “barrier” and *Hyd. char.* (hydraulic characteristic) of “0.01.”

8. Select the **OK** button.

7 Creating the Horizontal Well

The next step is to create a shallow horizontal well system to dewater the site. This can be accomplished using the nonvertical well capabilities available in MNW2.

7.1 Creating an MNW2 Coverage

First, it is necessary to 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. In the *Coverage Setup* dialog, change the *Coverage name* to "MNW2."
3. Change the *Default elevation* to "50."
4. In the list of *Sources/Sinks/BCs*, turn on the *Wells (MNW2)* option.
5. Select the **OK** button.

7.2 Creating the Horizontal Well

Now it is possible to 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," and "50," respectively**,** 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 that was just created by clicking on it.
6. Select the **Properties** button.
7. In the *Attribute Table* dialog, 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 times 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. Scroll to the right and enter "0.5" for *Rw*.

19. Select the **OK** button.

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

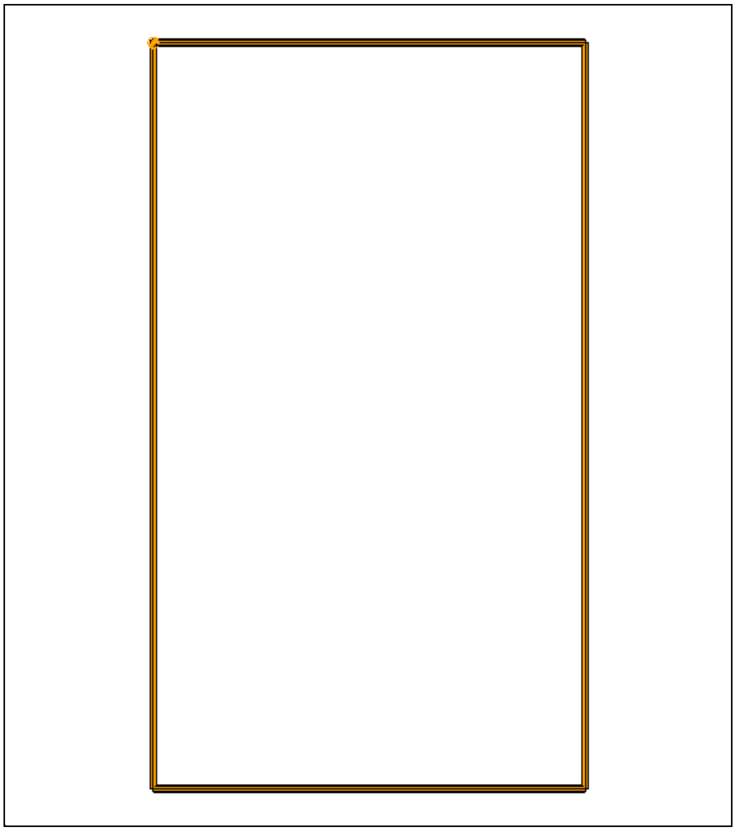


Figure 3 Horizontal well

8 Converting the Conceptual Model

It is now possible 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. 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.

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

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

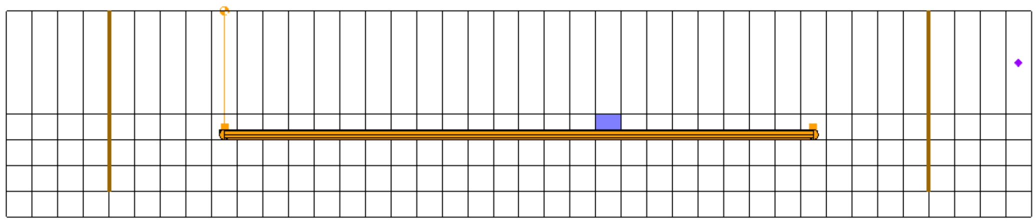


Figure 4 Model in front view

9 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.

9.1 Opening the MNW2 Package Dialog

1. Select the *MODFLOW* | *Optional Packages* | **MNW2 - Multi-Node Well** command to open the *MODFLOW Multi-Node Well (MNW2) Package* dialog.
2. Click on the **Wells** button.
3. In the *MNW2 Wells* dialog, click on the spreadsheet row for *WELL_A.*
4. Click **OK** to exit the *MNW2 Wells* dialog.
5. Click **OK** to exit the *MODFLOW Multi-Node Well (MNW2) Package* dialog.

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.

10 Running MODFLOW

Now it is possible to save the 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.

11 Viewing the Water Table

The user will now 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" dataset.
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 that was entered. The user might wish to adjust the pumping rate to see how it affects the water table.

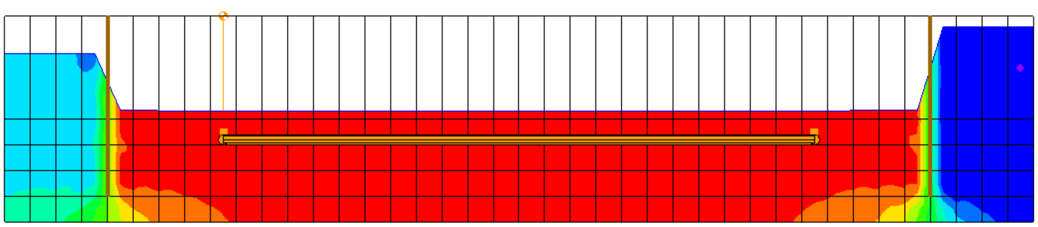


Figure 5 Water table at the end of the simulation

12 Saving the Model with a New Name

Now the user is going to examine the pump capacity curve option in MNW2. First, 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.

13 Modifying the Existing Well

The user 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. In the *Attribute Table* dialog, turn on the box in the *PUMPCAP* field. It might be necessary to scroll to the right.
6. Scroll further to the right and enter the value "50.0" for *Hlift*.
7. Scroll to the right again until the *Pump capacity curve* option is visible. Click on the ... button.
8. In the *XY Series Editor* dialog, 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**.

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

In step 7 and 8, the user 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 ft^3/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, the user specified 1.0 for the pump capacity multiplication. This means that the head-capacity relations defined in step 7 and 8 are used. If the user specifies any value less than or equal to 0, the head-capacity relations will be ignored for that particular stress period. The user 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, the user will want to use the exact the head-capacity curve for all the stress periods. Therefore, the user specified a constant value of 1.0 for the pump capacity multiplication factor.

14 Converting the Conceptual Model

The next step is to convert the changes to MODFLOW.

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

This should update the well.

15 Running MODFLOW

Now it is possible to save the 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.

16 Viewing the Water Table

The next step is to examine the new result

1. Expand the "mnw2_pumpcurve (MODFLOW)" item in the Project Explorer and select the "Head" dataset.
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. The user might wish to use the flow budget to see the change in pumping rate over time.

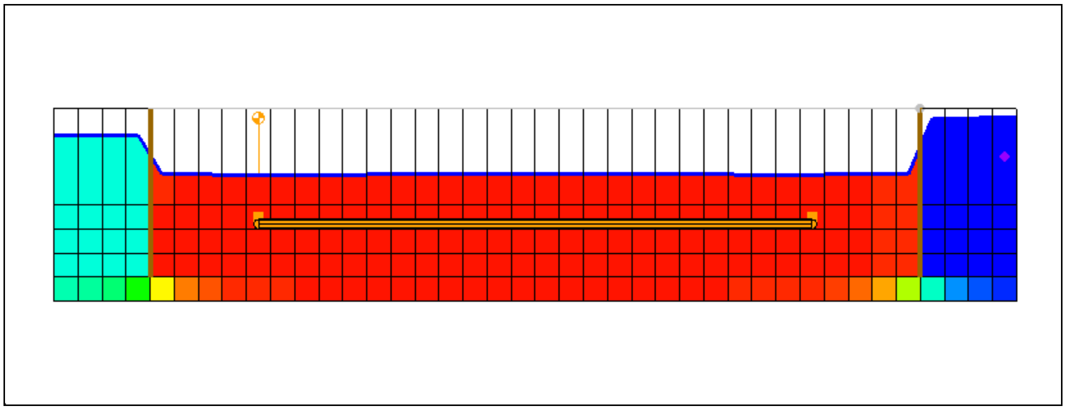


Figure 6 Water table after the first 5 days

17 Conclusion

This concludes the tutorial. Here are the key concepts in this tutorial:

- GMS supports the MNW2 package.
- It is possible to specify nonvertical wells using MNW2.
- It is possible to specify head-capacity pumping curves in MNW2.
- MNW2 wells can be created in the conceptual model and mapped to the grid.

