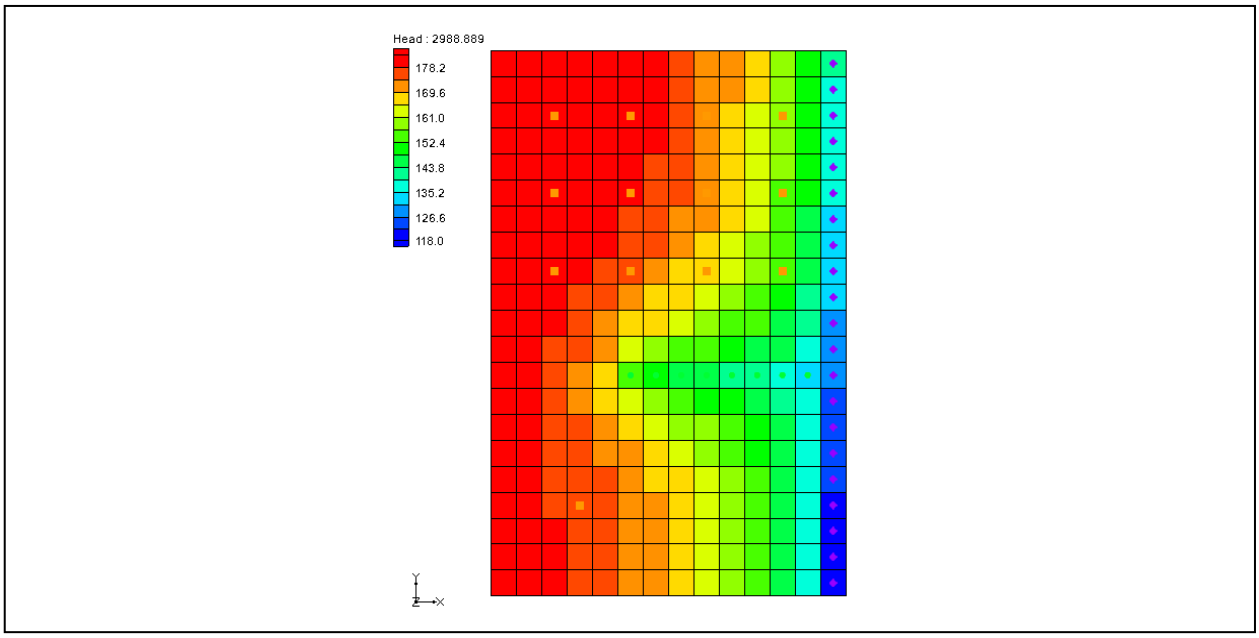
GMS 10.1 Tutorial

MODFLOW – MNW Package

Use the MNW package with the sample problem and a conceptual model



Objectives

Learn how to use the Multi-Node Well (MNW) package in GMS and compare it to the WEL package. Both packages can be used at the same time if desired. Examine the sample MNW model that comes with MODFLOW and then examine a different model that uses the conceptual model approach.

Prerequisite Tutorials

- MODFLOW – Conceptual Model Approach I

Required Components

- Map Module
- Grid Module
- MODFLOW

Time

- 30-45 minutes

AQUAVEO™

1 Introduction 2
2 Getting Started 4
2.1 Importing the Existing Model 5
2.2 Saving the Model with a New Name 6
2.3 Viewing the MNW Boundary Conditions 6
2.4 Reviewing the Source/Sinks Dialog 7
2.5 Running MODFLOW 8
2.6 Examining the Solution 9
3 Changing the Active Flag for the Multi-node Well 10
3.1 Running MODFLOW and Viewing the Solution 10
4 Drawdown Limited Wells 11
4.1 Running MODFLOW and Viewing the Solution 12
4.2 Drawdown Limited Multi-Node Wells 13
5 Create a Conceptual Model 15
5.1 Open the Existing Conceptual Model 15
5.2 Examining the Existing Solution 16
5.3 Changing the Model to Use MNW 16
5.4 Changing the Wells to MNW 16
5.5 Examine the MNW Package 17
5.6 Saving and Running MODFLOW 17
5.7 Examining the Solution 18
6 Changing to a Multi-Node Well 18
6.1 Examine the MNW Package 18
6.2 Saving and running MODFLOW 19
6.3 Viewing the Flow in the MNW Boundary Conditions 19
7 Conclusion 20

1 Introduction

The Multi-Node Well (MNW) package was developed to more accurately model wells that are completed in multiple aquifers or in a single heterogeneous aquifer, partially penetrating wells, and horizontal wells that can be influenced by the effects of dynamic changes in the distribution of pumping or intraborehole flow that can significantly alter groundwater flow.[1]

The problem in this tutorial (Figure 1 and Figure 2) is the same as the model used in the MNW documentation:

> The system consists of two aquifers that are separated by a 50-foot-thick confining unit. The upper aquifer is unconfined, has a hydraulic conductivity of 60 ft/d, and has a uniform base of 50 ft above the datum. The lower aquifer is confined and has a transmissivity of 15,000 ft^2/d. Storage coefficients of 0.05 and 0.0001 were assigned to layers 1 and 2, respectively. The 66-mi^2 area of the test problem was divided into 21

[1] Halford, K. J. and Hanson, R. T. (2002). *User Guide for the Drawdown-Limited, Multi-Node Well (MNW) Package for the U.S. Geological Survey's Modular Three-Dimensional Finite Difference Ground-Water Flow Model, Versions MODFLOW-96 and MODFLOW-2000*. U.S. Geological Survey Open-File Report 02-293, p.15-17. https://water.usgs.gov/nrp/gwsoftware/modflow2000/MNW_text.pdf .

 © Aquaveo 2016

rows of 14 columns. Uniform, square cells that measured 2,500 ft on a side were used throughout the simulated area. Specified heads and drains are assigned in layer 1 and are maintained at the same elevations for all stress periods.

A period of 1,000,970 days was simulated with 5 stress periods. The first two stress periods simulated steady-state conditions, which were achieved by having each stress period be 500,000 days long. Recharge during stress periods 1 and 2 was a uniform 7 inches per year (in./yr). No pumpage was extracted during stress period 1 but multi-node wells were simulated. About 950,000 ft^3/d of pumpage was extracted during stress period 2; this is about 35 percent of the total volumetric budget. Transient conditions were simulated during stress periods 3, 4, and 5, which were periods of 60, 180, and 730 days, respectively. Uniform recharge rates of 2, 0, and 12 in./yr, respectively, were applied during stress periods 3, 4, and 5. In addition to the simulation of two multi-node wells (wells A and B), there are 15 other single-node wells that have a combined discharge of 935,350 ft^3/d for stress periods 2 through 5.[2]

This tutorial discusses and demonstrates importing an existing MODFLOW simulation, running the simulation, examining the results to understand the MNW package options, and modifying a conceptual model to use MNW instead of the WEL package.

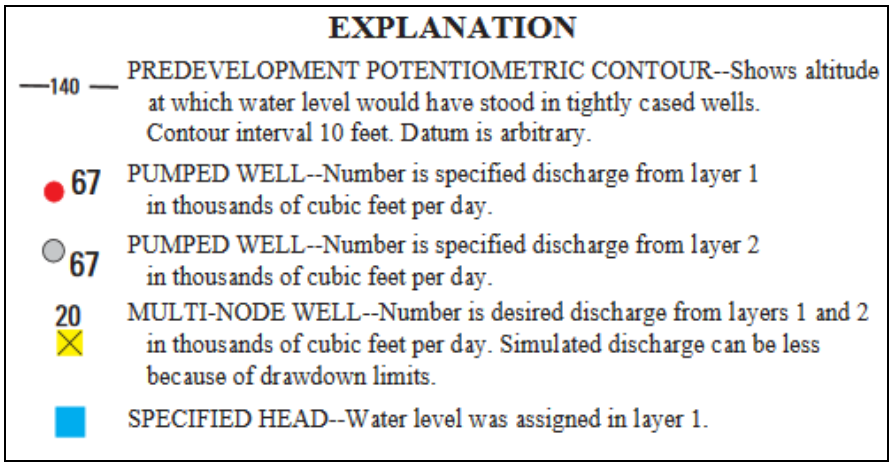


Figure 1 Legend for Figure 2[3]

[2] Halford (2002).

[3] Ibid.

 © Aquaveo 2016

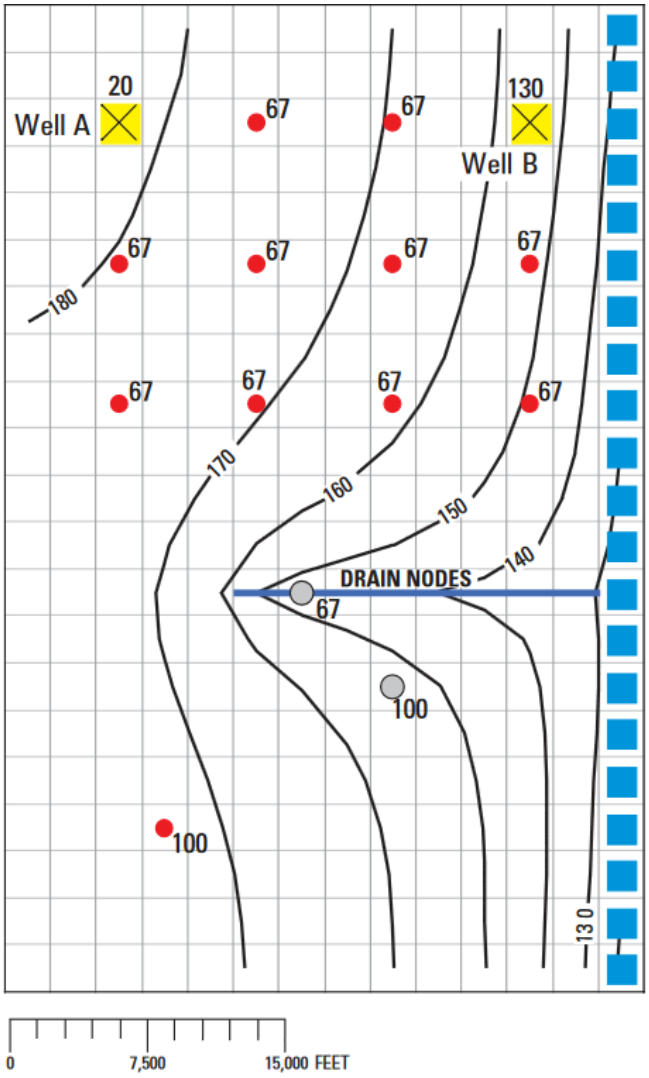


Figure 2 MNW example from the documentation[4]

2 Getting Started

Do the following to get started:

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

[4] Halford (2002).

© Aquaveo 2016

2.1 Importing the Existing Model

Start with a MODFLOW model that has already been created.

1. Click **Open** to bring up the *Open* dialog.
2. Select "All Files (*.*)" from the *Files of type* drop-down.
3. Browse to the *\Tutorials\MODFLOW\mnw* folder and select "mnw1.nam".
4. Click **Open** to exit the *Open* dialog and bring up the *MODFLOW Translator* dialog.
5. Click **OK** to accept the default options and initiate the translation of the file.
6. When MODFLOW 2000 terminates successfully, click **Done** to close the *MODFLOW Translator* dialog and finish importing the file.

A grid with symbols representing wells, drains, and specified head boundary conditions should appear (Figure 3).

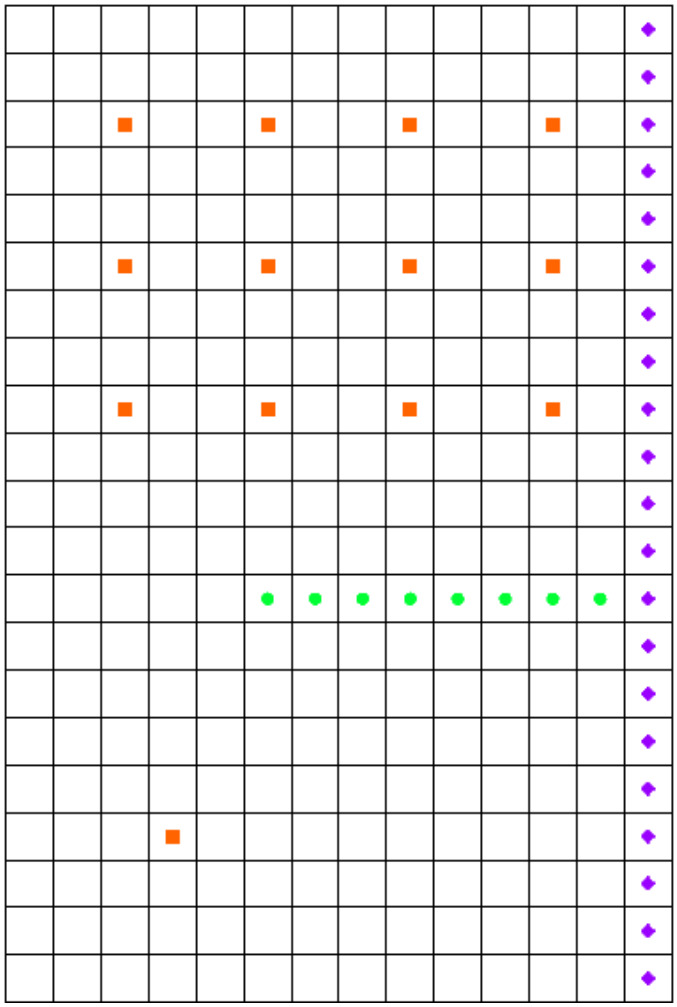


Figure 3 Imported MODFLOW model

© Aquaveo 2016

2.2 Saving the Model with a New Name

Before making changes, save the model with a new name.

1. Select *File* | **Save As…** to bring up the *Save As* dialog.
2. Select "Project Files (*.gpr)" from the *Save as type* drop-down.
3. "MNW.gpr" as the *File name*.
4. Click **Save** to save the project under the new name and close the *Save As* dialog.

2.3 Viewing the MNW Boundary Conditions

Before running the simulation, view the MNW boundary conditions.

1. Select *MODFLOW* | *Optional Packages* | **MNW1 – Multi-Node Well…** to open the *MODFLOW Multi-Node Well Package* dialog.

This dialog is used to edit existing MNW boundary conditions and to change options associated with the MNW package. The options located near the top of the dialog apply to the MNW package, while the spreadsheet near the bottom allows editing of individual MNW boundary conditions. Instead of repeating all of the MNW documentation here, review it on the USGS MODFLOW website as needed for more information on each input option.[5]

Now examine the MNW boundary conditions.

2. Notice the 17 MNW wells listed in the spreadsheet.

Most of these are single node wells. However, the wells named "Well-A" and "Well-B" are multi-node wells. Notice that for each of the wells labeled "Well-A," the Well ID is "1", and for each of the wells labeled "Well-B," the Well ID is "4".

3. Enter "2" for the *Stress period.*

Notice that nearly all of the wells have a specified pumping rate in this stress period except for "Well-A" and "Well-B". Only one of the boundary conditions associated with each of the multi-node wells has a desired pumping rate specified. The MNW package will determine how much of the desired flow should come from each of the nodes associated with a multi-node well.

GMS now has the Name, Active, and Well ID fields. "Name" is a label used to identify a boundary condition. "Active" is a flag used to determine if the boundary condition is used during a particular stress period. The "Well ID" field is used to identify multi-node

[5] "MNW1 – Multi-Node, Drawdown Limited Well Package", *Online Guide to MODFLOW*. U.S. Geological Survey, 2016.
http://water.usgs.gov/nrp/gwsoftware/modflow2000/MFDOC/index.html?mnw.htm.

 © Aquaveo 2016

wells. Refer to the MNW documentation[6] for a full explanation of each of the inputs to the MNW boundary conditions.

4. Click **OK** to close the *MODFLOW Multi-Node Well Package* dialog.

2.4 Reviewing the Source/Sinks Dialog

1. Switch to the 3D Grid module by selecting the " 3D Grid Data" item in the Project Explorer.
2. Using the **Select Cells** tool, select the 3D grid cell highlighted in Figure 4.

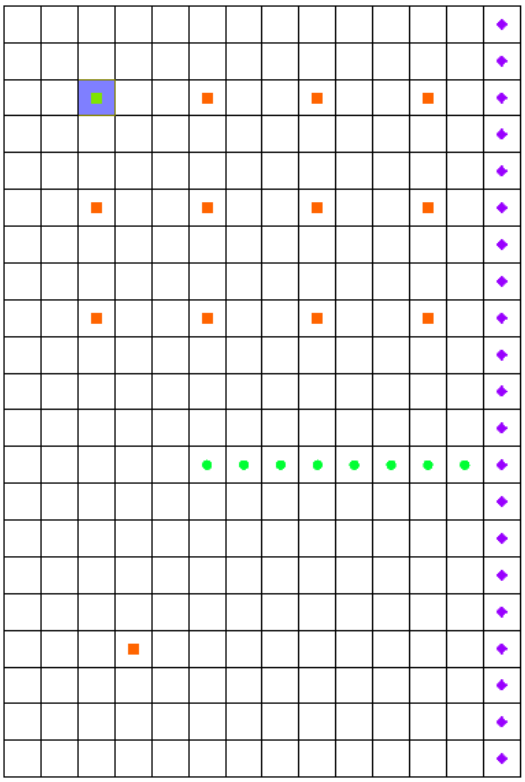


Figure 4 Selected MNW well cell

3. Right-click on the selected cell and select **Sources/Sinks…** to bring up the *MODFLOW Source/Sinks* dialog.

This dialog allows editing of the properties of a selected boundary condition, as well as adding of additional boundary conditions in the selected cells. Note that some of the properties available for MNW boundary conditions (such as Well ID) do not allow entering a time series. Therefore, the values entered in this dialog for these properties will be assigned to the boundary condition for all stress periods.

4. Select **OK** to exit the dialog.

[6] "MNW1" (2016).

© Aquaveo 2016

2.5 Running MODFLOW

Before running MODFLOW, it is necessary to change the output options to make it easier to see the results.

1. Select *MODFLOW* | **OC – Output Control…** to bring up the *MODFLOW Output Control* dialog.
2. In the *Output interval* section, select *Output at last time step of each stress period*.
3. Turn on *Save cell by cell flow terms to *.ccf file*.
4. Click **OK** to exit the *MODFLOW Output Control* dialog.

Now save these changes and run MODFLOW.

5. **Save** the project.
6. Select *MODFLOW* | **Run MODFLOW** to bring up the *MODFLOW* model wrapper dialog.
7. When MODFLOW finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
8. Click **Close** to close the *MODFLOW* model wrapper dialog.

Contours should appear on the grid similar to those shown in Figure 5.

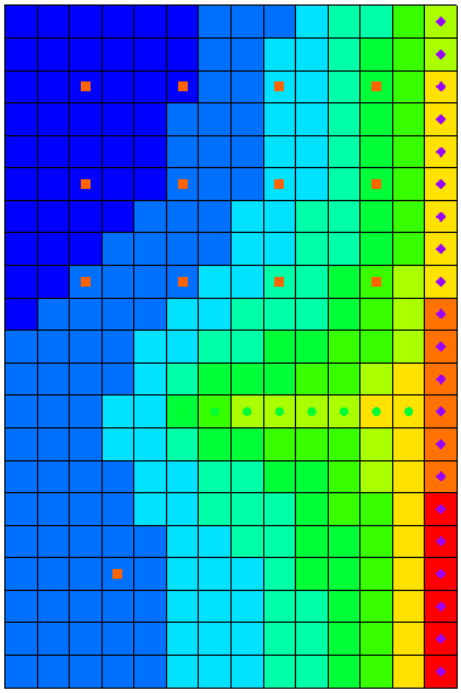


Figure 5 MODFLOW solution

9. **Save** the project with the new solution.

© Aquaveo 2016

2.6 Examining the Solution

Now look closely at the computed solution:

1. If necessary, re-select the grid cell selected in Figure 4 (Cell ID 31).
2. Switch to **Front View**.
3. Click **Display Options** to bring up the *Display Options* dialog.
4. In the section below the list on the left, enter "20.0" for the *Z magnification.*
5. Click **OK** to close the *Display Options* dialog.

From this view, it is possible to see the water table and the head contours (Figure 6). Notice that on the left side of the view, the head is greater in the top layer of the model. In contrast, the head on the right side of the view—where the specified head boundary condition is located—is less in layer 1 than in layer 2 of the model. Notice that the head in the selected cell is about "179.8".

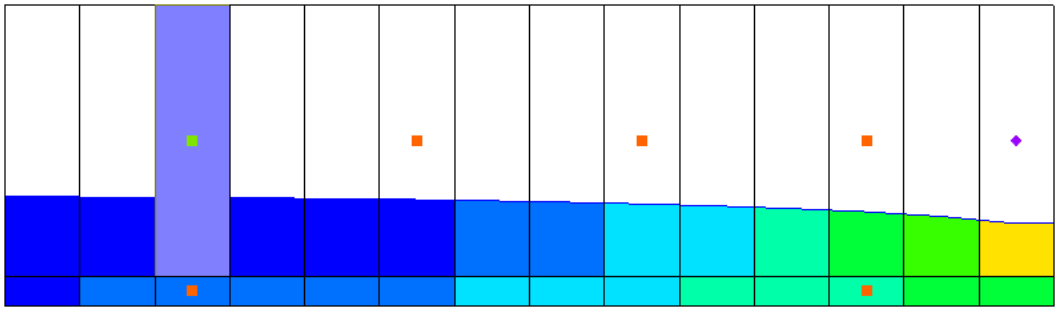


Figure 6 Front view showing water table and head contours

6. Select the cell directly below the one currently selected (Cell ID 325).

Notice that the head in the cell in the second layer is about "175.8". This means there is a potential for flow from layer 1 to layer 2 at these particular cells. It is also possible to see what effect the MNW multi-node well has on these grid cells.

7. Select "CCF (MNW.ccf)" in the Project Explorer, then right-click on it and select **CCF → Datasets**.
8. Select the new "MNW" dataset.
9. Click anywhere off the grid to unselect the grid cell.

Notice that flow is occurring between the multi-node well boundary conditions at these cells. This is an example of intraborehole flow that can occur when a well is completed in more than one aquifer. The effect of the multi-node wells is visible by looking at the *Flow Budget* dialog.

10. Select the two wells on the left side of the grid by selecting one cell and then holding down the *Shift* key while selecting the other.
11. Select *MODFLOW* | **Flow Budget…** to bring up the *Flow Budget* dialog.

 © Aquaveo 2016

Notice that values on the MNW row in the *Flow In* and the *Flow Out* columns are equal and opposite, just as expected. A flow of about "-16088.6" leaves the model cell in layer one and enters the model cell in layer two.

12. Click **OK** to exit the *Flow Budget* dialog.

3 Changing the Active Flag for the Multi-node Well

Now it is possible to see the effect of turning off the active flag for the multi-node well. Assume that "Well-A" was not constructed until after the first stress period in the model. Therefore, do not model the intraborehole flow or any pumping until after the first stress period. This can be accomplished by turning off the active flag for the boundary condition.

1. Select *MODFLOW* | *Optional Packages* | **MNW1 – Multi-Node Well…** to open the *MODFLOW Multi-Node Well Package* dialog.
2. In the spreadsheet at the bottom, uncheck the box in the *Active* column for both "Well-A" boundary conditions.
3. Change to *Stress period* to "2" just above the spreadsheet.

Notice that "Well-A" is active in stress period "2".

4. Click **OK** to exit the *MODFLOW Multi-Node Well Package* dialog.

3.1 Running MODFLOW and Viewing the Solution

Now it is possible to run MODFLOW to see how the solution has changed.

1. **Save** the project.
2. Click **Run MODFLOW** to bring up the *MODFLOW* model wrapper dialog.
3. When MODFLOW finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
4. Click **Close** to exit the *MODFLOW* model wrapper dialog.
5. Select and then right-click on "CCF (MNW.ccf)" in the Project Explorer and select **CCF → Datasets**.
6. Select the "MNW" dataset.

Notice that there is no intraborehole flow now at "Well-A" during the first stress period.

 © Aquaveo 2016

4 Drawdown Limited Wells

The MNW package also allows for wells to be limited by the drawdown in the cell containing the well. This feature allows a well to stop pumping when the head in the cells drops below a specified elevation. Change the drawdown for one of the wells and see the effect on the solution. However, first change the active flag back to its original state for "Well-A."

1. Select *MODFLOW* | *Optional Packages* | **MNW1 – Multi-Node Well…** to open the *MODFLOW Multi-Node Well Package* dialog.
2. In the spreadsheet at the bottom, check the box in the *Active* column for both "Well-A" boundary conditions.
3. Click **OK** to exit the *MODFLOW Multi-Node Well Package* dialog.

Now edit one of the MNW wells to illustrate the drawdown-limited feature.

4. Switch to **Plan View** .
5. Select the cell highlighted in Figure 7 (bottom right cell of the group of wells, Cell ID 124), then right-click and select **Sources/Sinks** to bring up the *MODFLOW Sources/Sinks* dialog.

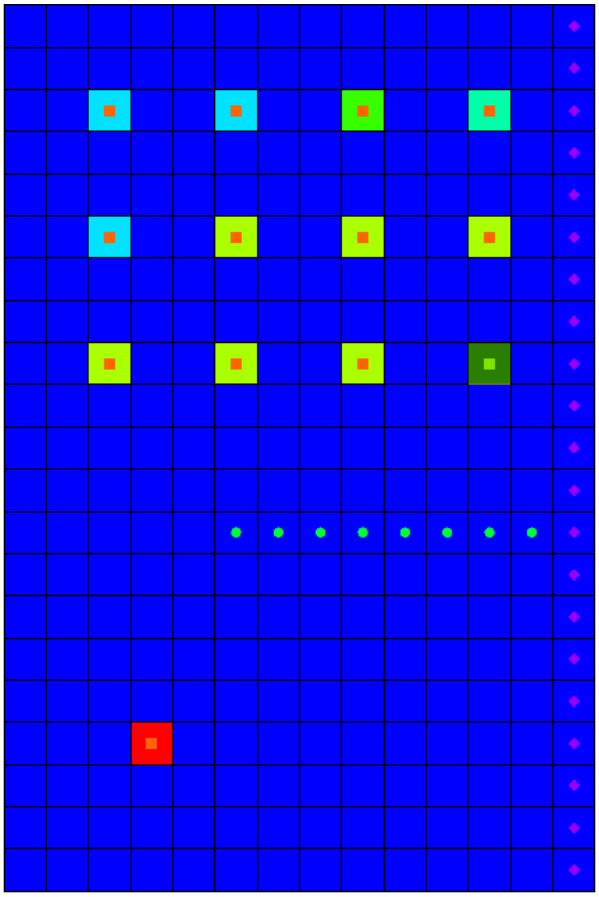


Figure 7 MNW boundary condition cell

© Aquaveo 2016

6. Scroll to the right in the spreadsheet to the *Hlim* column and click the button on row *124* to bring up the *XY Series Editor* dialog.
7. In the *Hlim* column on rows *2-5*, enter "142.0".
8. Click **OK** to exit the *XY Series Editor* dialog.
9. Click **OK** to exit the *MODFLOW Sources/Sinks* dialog.

4.1 Running MODFLOW and Viewing the Solution

Now run MODFLOW to see how the solution has changed:

1. **Save** the project.
2. Click **Run MODFLOW** to bring up the *MODFLOW* model wrapper dialog.
3. When MODFLOW finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
4. Click **Close** to import the solution and close the *MODFLOW* model wrapper dialog.
5. Select "CCF (MNW.ccf)" in the Project Explorer, then right-click on it and select **CCF → Datasets**.
6. Select the "MNW" dataset and change the active time step to the second time step listed in the Time Step Window below the Project Explorer.

Notice that the flow at the cell that was edited is about "-5754.48".

7. Select the "Head" dataset.

Notice that the head in this cell is about "143.29". Remember, the desired flow rate (*Qdes*) that was specified for the well was "66850.0". Nevertheless, the computed flow for this drawdown limited well was only "6130". Now it is possible to look at the head at the next output time.

8. Select the third time step listed in the Time Step Window. Notice that the head at the cell is about "142.37".
9. Change to the "MNW" dataset and notice that the flow in this time step is "0.0".

Even though the head value is high enough, the well has been deactivated during this stress period. Find out why by examining the well's settings.

10. Select *MODFLOW* | *Optional Packages* | **MNW1 – Multi-Node Well…** to open the *MODFLOW Multi-Node Well Package* dialog.
11. Change *Stress period* to "2" and notice the settings for Cell ID 124 near the bottom of the spreadsheet.
12. Change *Stress period* to "3".

© Aquaveo 2016

Notice that—for this stress period—the *QCUT* value has been set to "Percent (2)" with a *Qfrcmn* value of "45.0" (a percentage). The *Qfrcmn* value is the minimum pumping rate required for the well to remain active. With a desired flow rate (*Qdes*) of "-66850.0", a flow rate of "-30082.5" is needed for the well to remain active. For the previous stress period, *QCUT* was set to "None (0)", allowing the well to be active.

13. Click **OK** to exit the *MODFLOW Multi-Node Well Package* dialog.

4.2 Drawdown Limited Multi-Node Wells

For multi-node wells, the limiting water level needs to be specified for the first multi-node cell listed in the MNW Package dialog.

1. Select *MODFLOW* | *Optional Packages* | **MNW1 – Multi-Node Well…** to open the *MODFLOW Multi-Node Well Package* dialog.
2. Change *Stress period* to "2".

Notice that (for this stress period) the first "Well-A" has a flow rate of "-20000".

3. Scroll to the right in the spreadsheet so the *Hlim* and *DD* columns are visible.

Notice that the *Hlim* value is set to "50" and the *DD* is set to "Relative (2)". When using relative drawdown, the *Hlim* value used by MODFLOW is calculated by either adding or subtracting *Hlim* from *Href*. When the *Qdes* value is greater than zero, *Hlim* is added to *Href*, and when the *Qdes* value is less than zero, *Hlim* is subtracted from *Href*. To demonstrate how the sign of the *Qdes* value can affect the model, adjust the *Qdes* values for "Well-A".

4. Scroll to the left in the spreadsheet to the *Qdes (flow) (ft^3/d)* column and enter "-1.0" on row *1* ("Well-A").
5. Enter "-19999.0" for on row 2 (the second "Well-A" cell). The combined value of *Qdes* for "Well-A" remains "-20000".
6. Click **OK** to exit the *MODFLOW Multi-Node Well Package* dialog.

Before running MODFLOW with these changes, it is necessary to check head and multi-node well values in the first cell to verify that they will remain the same.

7. Using the **Select Cells** tool, select the top right well cell (Well-A, Cell ID 31, see Figure 8).
8. Select the second time step in the Time Step Window. Notice that the flow for the cell is about "-20120.7".
9. Select the "Head" dataset in the Project Explorer. Notice that the head value is about "164.60".

 © Aquaveo 2016

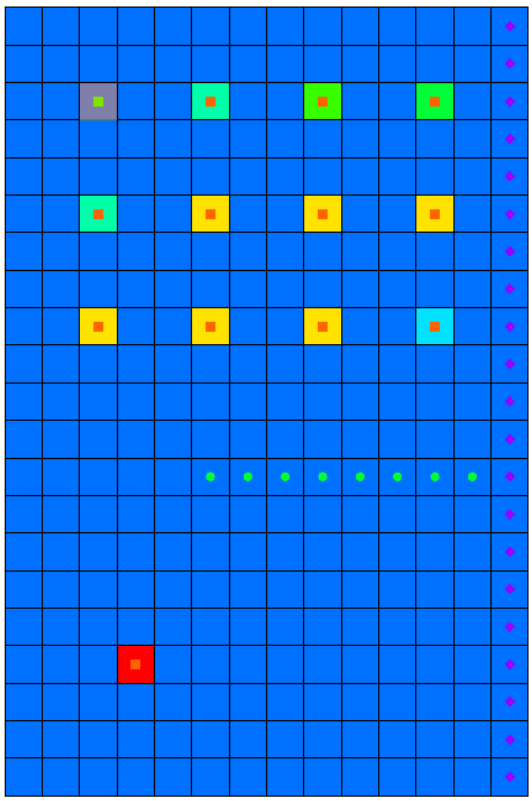


Figure 8 Selected MNW well cell

10. **Save** the project.
11. Click **Run MODFLOW** to bring up the *MODFLOW* model wrapper dialog.
12. When MODFLOW finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
13. Click **Close** to import the solution and close the *MODFLOW* model wrapper dialog.
14. Select the "Head" dataset and select the second time step in the Time Step Window. Notice that the head in this cell remains at about "164.60".
15. Select "CCF (MNW.ccf)" in the Project Explorer, then right-click on it and select **CCF → Datasets**.
16. Select the "MNW" dataset and select the second time step in the Time Step Window. Notice that the flow remains at about "-20120.7".

Now adjust the *Qdes* values so that the sum remains the same but the sign of the *Qdes* for the first cell is positive.

17. Select *MODFLOW* | *Optional Packages* | **MNW1 – Multi-Node Well…** to open the *MODFLOW Multi-Node Well Package* dialog.
18. Change *Stress period* to "2".

 © Aquaveo 2016

19. On row *1* (the first "Well-A" cell), enter "1.0" in the *Qdes (flow)(ft^3/d)* column.
20. On row *2* (the second "Well-A" cell), enter "-20001.0" in the *Qdes (flow)(ft^3/d)* column.
21. Click **OK** to exit the *MODFLOW Multi-Node Well Package* dialog.
22. **Save** the project.
23. Click **Run MODFLOW** to bring up the *MODFLOW* model wrapper dialog.
24. When MODFLOW finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
25. Click **Close** to import the solution and close the *MODFLOW* model wrapper dialog.
26. Select the "Head" dataset and select stress period 2 in the Time Step Window. Notice that the head in this cell has changed to about "165.61".
27. Select "CCF (MNW.ccf)" in the Project Explorer, then right-click on it and select **CCF → Datasets**.
28. Select the "MNW" dataset and select the second time step in the Time Step Window.

Notice that the flow has changed to about "-13809.84". This change has been caused by a higher *Hlim* value, which was in turn brought about by changing the sign of the *Qdes* value in the first "Well-A" cell. Less flow could be taken from the model by the well to maintain a higher head value.

5 Create a Conceptual Model

The next step is to examine how to use a conceptual model with MNW data. We'll do this by taking the finished model for the "MODFLOW – Conceptual Model Approach" tutorial and changing it to use the MNW package.

5.1 Open the Existing Conceptual Model

1. Before opening the conceptual model, **Save** the grid-based MNW model.
2. Click **New** to reset GMS back to the default settings.
3. Click **Open** to bring up the *Open* dialog.
4. Select "Project Files (*.gpr)" from the *Files of type* drop-down.
5. Browse to the *Tutorials\MODFLOW\modfmap\sample2* directory and select "modfmap2.gpr".
6. Click **Open** to import the project and exit the *Open* dialog.

 © Aquaveo 2016

Before making any changes, save the project under a new name.

7. Select *File* | **Save As…** to bring up the *Save As* dialog.
8. Select "Project Files (*.gpr)" from the *Save as type* drop-down.
9. Browse to the *Tutorials\MODFLOW\mnw* directory.
10. Enter "MNWmap.gpr" as the *File name*.
11. Click **Save** to save the project under the new name and close the *Save As* dialog

5.2 Examining the Existing Solution

Before changing to the MNW package, look at the flow budget for the existing solution:

1. Select *MODFLOW* | **Flow Budget…** to bring up the *Flow Budget* dialog.

Notice the flow budget for the Well package has a flow out rate of about "-2344.60".

2. Click **OK** to exit the *Flow Budget* dialog.

5.3 Changing the Model to Use MNW

To change to the MNW package, first the WEL package needs to be removed from MODFLOW.

1. Select *MODFLOW* | **Global Options…** to open the *MODFLOW Global/Basic Package* dialog.
2. Click **Packages…** to bring up the *MODFLOW Packages / Processes* dialog.
3. In the *Optional packages / processes* section, turn off the *WEL1 – Well* to disable the WEL package.
4. Click **OK** to exit the *MODFLOW Packages / Processes* dialog.
5. Click **OK** to exit the *MODFLOW Global/Basic Package* dialog.

5.4 Changing the Wells to MNW

1. Fully expand the " Map Data" folder.
2. Right-click on the " Sources&Sinks" coverage under the " East Texas" conceptual model in the Project Explorer and select **Coverage Setup…** to bring up the *Coverage Setup* dialog.
3. In the *Sources/Sinks/BCs* section, turn on *Wells (MNW)*.
4. Click **OK** to exit the *Coverage Setup* dialog.

 © Aquaveo 2016

5. Right-click on "Sources&Sinks" and select **Attribute Table…** to bring up the *Attribute Table* dialog.
6. On the *All* row of the spreadsheet, select "well (MNW)" from the *Type* drop-down.
7. On both row *16* ("well1") and row *17* (well2), scroll to the right and uncheck the box in the *Use screen* column.
8. Scroll to the right and enter "-50.0" in the *Qdes (m^3/d)* column on row *16*.
9. Enter "-300.0" in the *Qdes (m^3/d)* column on row *17*.
10. Click **OK** to exit the *Attribute Table* dialog.

The conceptual model is set up so now it can be mapped to the MODFLOW grid.

11. Click **Map → MODFLOW** to bring up the *Map → Model* dialog.
12. Click **OK** to accept the defaults and close the *Map → Model* dialog.

5.5 Examine the MNW Package

The next step is to review the data in MODFLOW that was mapped from the conceptual model.

1. Select *MODFLOW* | *Optional Packages* | **MNW1 – Multi-Node Well…** to bring up the *MODFLOW Multi-Node Well Package* dialog.

Review the two MNW boundary conditions that were created.

2. Click **OK** to exit the *MODFLOW Multi-Node Well Package* dialog.

5.6 Saving and Running MODFLOW

Before saving the changes and running MODFLOW, adjust the output control.

1. Select *MODFLOW* | **OC – Output Control…** to bring up the *MODFLOW Output Control* dialog.
2. In the *Other output* section, turn off **.hff file for transport*.
3. Click **OK** to exit the *MODFLOW Output Control* dialog.
4. **Save** the project.
5. Click **Run MODFLOW** to bring up the *MODFLOW* model wrapper dialog.
6. When MODFLOW finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
7. Click **Close** to import the solution and close the *MODFLOW* model wrapper dialog.

© Aquaveo 2016

8. **Save** the project with the new solution.

5.7 Examining the Solution

Look at the flow budget for the new solution:

1. Select *MODFLOW* | **Flow Budget…** to bring up the *Flow Budget* dialog.

Notice the flow budget for the MNW package has the same approximate flow out rate of "-2344.6".

2. Click **OK** to exit the *Flow Budget* dialog.

6 Changing to a Multi-Node Well

Now create a multi-node well from the map data.

1. Right-click on "Sources & Sinks" and select **Attribute Table…** to bring up the *Attribute Table* dialog.
2. In row *17* ("well2"), scroll to the right and enter "1" in the *From layer* column.
3. Click **OK** to exit the *Attribute Table* dialog.

The conceptual model can now be mapped to the MODFLOW grid.

4. Click **Map** → **MODFLOW** to bring up the *Map* → *Model* dialog.
5. Click **OK** to accept the defaults and close the *Map* → *Model* dialog.

6.1 Examine the MNW Package

Now look at the data in MODFLOW that was mapped from the conceptual model.

1. Select *MODFLOW* | *Optional Packages* | **MNW1 – Multi-Node Well…** to bring up the *MODFLOW Multi-Node Well Package* dialog.

Review the various MNW boundary conditions that were created.

2. Notice that "well2" is associated with two MNW boundary conditions and that the Well ID is 1 for each of the boundary conditions.
3. Notice also that the Qdes has only been assigned to one of the "well2" boundary conditions.

The MNW package will calculate the amount of flow that each of the wells will take from the aquifer.

4. Click **OK** to exit the dialog.

 © Aquaveo 2016

6.2 Saving and running MODFLOW

Now it is possible to save the changes and run MODFLOW. Before doing so, adjust the parameters associated with the solver.

1. Select *MODFLOW* | **PCG2 – Pre. Conj.-Gradient Solver…** to bring up the *MODFLOW PCG Package* dialog.
2. Enter "100" as the *Maximum number of outer iterations (MXITER).*
3. Enter "0.5" as the *Relaxation parameter (RELAX).*
4. Click **OK** to exit the *MODFLOW PCG Package* dialog.
5. Select *File* | **Save As…** to bring up the *Save As* dialog.
6. Select "Project Files (*.gpr)" from the *Save as type* drop-down.
7. Enter "MNWmap2.gpr" as the *File name*
8. Click **Save** to save the project under the new name and close the *Save As* dialog.
9. Click **Run MODFLOW** to bring up the *MODFLOW* model wrapper dialog.
10. When MODFLOW finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
11. Click **Close** to import the solution and close the *MODFLOW* dialog.

6.3 Viewing the Flow in the MNW Boundary Conditions

View the computed flow out of each of the MNW boundary conditions associated with well2 by doing the following:

1. Select "3D Grid Data" to make it active.
2. **Zoom** in around the well on the right side of the model.
3. Using the **Select Cell** tool, select the cell containing the well (Cell ID 1944).
4. Select *MODFLOW* | **Flow Budget…** to bring up the *Flow Budget* dialog.

Notice that the flow out of the well in the top layer is about "-170.08". Now view the flow out of the well in the second layer.

5. Click **OK** to exit the *Flow Budget* dialog.
6. Using the Mini Grid Toolbar, change the layer to "2".
7. Select the cell containing the well (Cell ID 5024) using the **Select Cell** tool.
8. Select *MODFLOW* | **Flow Budget…** to bring up the *Flow Budget* dialog.

Notice that the flow rate for this well is about "-129.92".

© Aquaveo 2016

9. Click **OK** to exit the *Flow Budget* dialog.
10. **Save** the project.

7 Conclusion

This concludes the "MODFLOW – MNW Package" tutorial. The following key concepts were discussed and demonstrated in this tutorial:

- GMS supports both the WEL and MNW packages. Both packages can be used at the same time if desired.
- The MNW package produces the same results as the WEL when there are no multi-node wells.
- MNW data can be viewed and edited in the MNW Package dialog.

© Aquaveo 2016