GMS 10.3 Tutorial
MODFLOW – Recharge

Objectives
Learn about inputs to the MODFLOW Recharge package.

Prerequisite Tutorials
- MODFLOW – Grid Approach

Required Components
- Grid Module
- Map Module
- MODFLOW

Time
- 25–40 minutes
1 Introduction

The Recharge Package (RCH) is used by MODFLOW to simulate the deep percolation of water that reaches an aquifer. The purpose of this tutorial is to demonstrate how recharge can be entered, edited, and visualized in GMS. The example will use a very simplistic model to illustrate the various ways that recharge can be specified. This tutorial is recommended for users who want to explore in depth all of the options available in the recharge package. This tutorial is not meant to demonstrate common workflows for implementing recharge in a typical ground water model.

1.1 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.

2 Importing the Project

First, to import the modeling project:

1. Click Open to bring up the Open dialog.

2. Select “Project Files (*.gpr)” from the Files of type drop-down.

3. Browse to the Tutorials\MODFLOW\recharge directory and select “mf2k_recharge.gpr”.

4. Click Open to import the project and close the Open dialog.

The imported project should appear similar to Figure 1.
This is a three layer steady state MODFLOW model with nine cells in each layer. The model has one specified head cell and recharge. The recharge is specified to be applied to layer 1.

### 3 Recharge Package

Now to look at the inputs in the recharge package.

1. Double-click on the “RCH” item in the Project Explorer to bring up the MODFLOW Recharge Package dialog.

The top of the dialog has the Recharge Option (NRCHOP) section. This variable controls where the recharge is specified in the model. The current option, “(1) Recharge only at top layer”, means that recharge will only be applied to cells in layer 1. There are two other options: “(2) Recharge at specified vertical cells” and “(3) Recharge at highest active cell”. Each of these items will be explained in greater detail later.

The Stress period section is where the current stress period is selected. Changing the stress period will change the contents in the spreadsheet at the bottom of the dialog and the value of the multiplier.

The spreadsheet at the bottom of the dialog shows that values in the different recharge arrays; “RECH. Flux” is currently shown. This value has units of length/time and is specified for each cell in layer 1. The amount of water that will enter the MODFLOW cell from recharge will be this value multiplied by the area of the cell.
There are four buttons on the upper right side of the dialog. The **Edit all Use previous/Multipliers** will be explained later. The **2D Dataset → Array** button is used to select a dataset from a matching 2D grid and apply that dataset to the recharge array. The **Array → 2D Dataset** creates a dataset on a matching 2D grid from the recharge data. The **Constant → Array** button assigns a constant value to the recharge array.

2. Click **OK** to close the *MODFLOW Recharge Package* dialog.

## 4 Contouring the Recharge Values

The recharge values can be visualized by making the “*RCH Rate*” item the active dataset in the Project Explorer.

1. Select the “*RCH Rate*” item in the Project Explorer.

The view will look like Figure 2 below.

![RCH Rate contours](image)

*Figure 2  RCH rate contours*

Only the top layer of the grid is visible because recharge is only applied to the top of the grid. The color is the same in each cell because the recharge values are constant. The recharge values can be edited in the *MODFLOW Recharge Package* dialog and they can be edited by selecting a cell.

2. Using the **Select Cells** tool, select the cell shown in Figure 3.
3. Right-click on the selected cell and choose Sources/Sinks to open the MODFLOW Sources/Sinks dialog.

4. Select “Recharge” from the list on the left side of the dialog.

5. Enter “0.0002” for the Flux (ft/d) value in the spreadsheet.

6. Select OK to exit the MODFLOW Sources/Sinks dialog.

The view will update and appear like Figure 4.

4.1 Effect of IBOUND

The IBOUND can affect recharge.
1. Double-click on the same cell where the recharge rate was edited. The 3D Grid Cell Properties dialog will appear with the MODFLOW tab active.

2. Change the value in the IBOUND row to “Inactive”.

3. Click OK to exit the 3D Grid Cell Properties dialog.

The cell is no longer visible because the IBOUND value is inactive (0) as shown in Figure 5.

![Figure 5](image)

*Figure 5  The inactive cell is no longer visible*

This cell will not be included in MODFLOW’s computations. The recharge value assigned to that cell will be ignored.

4. Double-click on the “RCH” item in the Project Explorer to bring up the MODFLOW Recharge Package dialog.

Notice in the spreadsheet that the first cell is not editable. Again, this is because the recharge to that cell will be ignored by MODFLOW.

5 **Changing the Recharge Option (NRCHOP)**

Often it is useful for the recharge that would have been applied to a cell in layer 1 to be applied to a cell in a lower layer below the original cell. If for some reason the cell in layer 1 became dry during a simulation the recharge applied to that cell would be ignored by MODFLOW. Generally it is desired that the recharge value would be applied to a lower cell. This can be accomplished by changing the Recharge Option.

1. Change the Recharge Option (NRCHOP) to “(3) Recharge at highest active cell”.

Notice that the first item in the spreadsheet is now editable because there is an active cell below the inactive cell in layer 1.
2. Select OK to exit the MODFLOW Recharge Package dialog.

The recharge dataset has now updated as well. The view will look like Figure 6.

![Figure 6 RCH rate contours](image)

Now to inactivate all the cells in the column below the inactive cell.

3. Right-click on the “Ibound” item in the Project Explorer and select Properties to open the Ibound Array dialog.

4. Change the value in the Layer edit field to “2”. The spreadsheet will update with values from layer 2.

5. Change the value to “0” in row 1 column 1.

6. Change the value in the Layer edit field to “3”.

7. Again, change the value to “0” in row 1 column 1.

8. Click OK to exit the Ibound Array dialog.

Notice that no cells in the column below cell id 1 are visible.

9. Double-click on the “RCH” item in the Project Explorer to bring up the MODFLOW Recharge Package dialog.

Notice that the first item in the spreadsheet is not editable. If no cells are active in a column of the grid then the recharge value will be ignored by MODFLOW.

5.1 Recharge at specified vertical cells

The last option demonstrated is “Recharge at specified vertical cells”. This option allows recharge to be assigned to a particular cell. When this option is selected another array (IRCH) is available for editing.
1. Change the *Recharge Option (NRCHOP)* to “(2) Recharge at specified vertical cells”.

2. Change the item in the *View/Edit* dropdown list to “IRCH. Layer indicator”.

Notice that the first item in the spreadsheet is not editable. There are no active cells in this column.

3. Change the value in row 1 column 2 to “2” (for layer 2).

4. Change the value in row 1 column 3 to “3” (for layer 3).

5. Click **OK** to exit the *MODFLOW Recharge Package* dialog.

The “RCH Rate” dataset has updated and the view will look like Figure 7.

![Figure 7 RCH rate contours](image)

### 6 Transient Model

Now to look at the recharge package data with a transient model.

1. Select the *File | New* command and select **Don’t Save** at the prompt.

2. Click **Open** to bring up the *Open* dialog.

3. Select “Project Files (*.gpr)” from the *Files of type* drop-down.

4. Browse to the *Tutorials\MODFLOW\recharge* directory and select “mf2k_recharge_trans.gpr”.

5. Click **Open** to import the project and close the *Open* dialog.

This is the same MODFLOW model except that it is transient with four stress periods.
6. Double-click on the “RCH” item in the Project Explorer to bring up the MODFLOW Recharge Package dialog.

This model is using the “(2) Recharge at specified vertical cells” option. The “RECH. Flux” and the “IRCH. Layer indicator” data change with the stress periods.

7. Use the arrow buttons to cycle through the Stress period to see how the RECH. Flux data changes in each stress period.

Notice that the Use previous check box is checked for the third stress period. This means that the data from stress period 2 is reused in stress period 3 for the “RECH. Flux”. Also, notice that the Multiplier is “2.0” in stress period 4 instead of “1.0”. This means that the values in the “RECH. Flux” array will be multiplied by 2.0 when MODFLOW runs. For transient models with many stress periods it can be difficult to edit the Use previous and the Multiplier by cycling through the stress periods. All of the Use previous and Multiplier values can be edited by selecting the Edit All Use previous/Multipliers button.

8. Click the Edit All Use previous/Multipliers button.

A dialog comes up with the Use previous and Multiplier values for each stress period. This allows for quick editing of many stress periods. A value of 0 for Use previous will leave the check box unchecked while a non-zero value will set the check on.

9. Click OK to close the Edit All Use Previous/Multipliers dialog.

10. Change the item in the View/Edit dropdown list to “IRCH. Layer indicator”.

11. Use the arrow buttons to cycle through the Stress period to see how the “IRCH. Layer indicator” data changes in each stress period.

12. Click OK to close the MODFLOW Recharge Package dialog.

6.1 Recharge Dataset

1. Select the “RCH Rate” item in the Project Explorer.

The view will look like Figure 8.
Notice that cells in different layers are visible because of the options set in the MODFLOW Recharge Package dialog. Also notice that the Time Step Window (Figure 9) is available for selecting different time steps for the "RCH Rate" dataset. These time steps correspond to the MODFLOW stress periods. Again take note that the times that are displayed are in date/time format because a reference time has been associated with the MODFLOW model.

2. Cycle through the times steps by selecting each one in the Time Step Window.

Notice that either the recharge rate or the layer assignment changes with each stress period.
6.2 Cell Editing of Recharge

When the “RCH Rate” dataset is active it is clear which cells have recharge applied to them for a particular stress period. When a different dataset is active different cells may be active than those with the recharge dataset. This can cause some confusion when editing the recharge for cells. The clearest way to see which cells have recharge applied is to make the “RCH Rate” dataset active.

1. Select the first time step in the Time Step Window for the “RCH Rate” dataset.

The view will look like Figure 8.

2. Using the Select Cells tool, select the cell shown in Figure 10.

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

Notice that for row 1 in the column Layer that the spreadsheet the value is “<transient>”. As expected the assigned layer varies with time. The layers can be edited by selecting the small button above the drop down arrow in the cell with the “<transient>” value.

4. Click the top button in row 1 of the Layer column to open an XY Series Editor dialog where the layer values for each stress period can be edited.

5. Change the value for Layer in the first row of the spread sheet to “1”.

6. Click OK to exit the XY Series Editor dialog.

7. Click OK to exit the MODFLOW Sources/Sinks dialog.
The display will update and the visible cells on the grid will change. The view will look like Figure 11.

Changing the layer updated the “RCH Rate” dataset so that a different cell would be active for the first time step of the dataset. This is why the top cell is now visible. In addition, because the layer value changed for the first stress period and it is now different than the layer value for the second stress period the Use previous option has been changed in the MODFLOW Recharge Package dialog.

8. Double-click on the “RCH” item in the Project Explorer to bring up the MODFLOW Recharge Package dialog.

9. Change the item in the View/Edit dropdown list to “IRCH. Layer indicator”.

10. Click the Edit All Use previous/Multipliers button to open a Properties dialog.

Notice that the value for Use Previous for stress period 2 (row 2) is now “0”. Prior to editing the layer for the selected cell this value was “1”.

11. Click Cancel to close the Properties dialog.

12. Click Cancel to close the MODFLOW Recharge Package dialog.

Recharge can be edited even if the “RCH Rate” dataset is not the active dataset.

13. Select the “elevation” item in the Project Explorer.

14. Using the Select Cells tool, select the cell shown in Figure 12.
15. Right-click on the selected cell and select **Sources/Sinks** to bring up the **MODFLOW Sources/Sinks** dialog.

Even though recharge is not assigned to this cell, GMS allows recharge to be edited when this cell is selected. Recharge could be assigned to the selected cell by editing the value of the *Layer*.

16. Click **OK** to exit the **MODFLOW Sources/Sinks** dialog.

## 7 Conceptual Model

Using the conceptual model to define recharge is shown in various other GMS tutorials. Here, the focus will be on how Map→MODFLOW is designed to work with recharge.

1. Select the **File | New** command and select **Don’t Save** at the prompt.

2. Click **Open** to bring up the **Open** dialog.

3. Select “Project Files (*.gpr)” from the **Files of type** drop-down.

4. Browse to the **Tutorials\MODFLOW\recharge** directory and select “mf2k_recharge_con_mod.gpr”.

5. Click **Open** to import the project and close the **Open** dialog.

The view will look like Figure 13. The active coverage has a single polygon with recharge assigned to it. The MODFLOW model currently does not include the recharge package.
6. Right-click on the “recharge 1” coverage and select the Map to MODFLOW/MODPATH command.

Notice in the Project Explorer that the recharge (RCH) package is now part of the MODFLOW simulation. The values from the polygon in the coverage have been transferred to the associated cells in the grid. Now to view where the values have been assigned.

7. Select the “RCH Rate” item in the Project Explorer.

The view will look like Figure 14. The blue cells have been assigned a value for recharge and the red cells have a value of zero. Notice that the cell in the center of the grid was assigned a recharge value even though it is only slightly overlapped by the polygon. Each cell is given the same recharge value even though the area of overlap with the polygon is different for each cell.
8. Double-click on the “RCH” item in the Project Explorer to bring up the MODFLOW Recharge Package dialog.

Notice that the Recharge option (NRCHOP) is set to “(3) Recharge at highest active cell”. If recharge is not part of the MODFLOW model and the Map→MODFLOW command is executed with a recharge coverage then the recharge package will be initialized and NRCHOP will be set to (3).

9. Select OK to exit the MODFLOW Recharge Package dialog.

10. Select the “recharge 2” coverage in the Project Explorer to make it the active coverage.

This coverage has two polygons. Notice that both polygons overlap with the cell in the center of the grid.

11. Right-click on the “recharge 2” coverage and select the Map to MODFLOW/MODPATH command.

The view will look like Figure 15. The blue cells were assigned recharge from the polygon on the right and the green cells were assigned recharge from the polygon on the left. The red cells have a value of zero assigned. Notice that the center cell is blue; the polygon on the right has a larger overlapping area so the center cell is associated with the polygon on the right.
12. Right-click on the “recharge 1” coverage and select the Map to | MODFLOW/MODPATH command.

The view should look like Figure 14. Notice that the center cell has been assigned a value from the polygon in the “recharge 1” coverage and all of the other cells have a value of 0.0 assigned. When the Map→MODFLOW command is executed with a recharge coverage, the recharge is initially set to zero and then the values from the polygons are applied.

13. Right-click on the Conceptual Model item in the Project Explorer and select the Map to | MODFLOW/MODPATH command to open the Map → Model dialog.

14. Select All applicable coverages and click OK to close the Map → Model dialog.

The view will look like Figure 16. Notice that the center cell is blue and has a value of 0.0003 assigned. This is because the “recharge 1” coverage assigned a value of 0.0001 and the “recharge 2” coverage added a value of 0.0002. So the final value in the cell is the sum of values from each coverage that was mapped.
The specified layer is not assigned using the conceptual model. If the recharge package is initialized and the NRCHOP is set to “(2) Recharge at specified vertical cells” then GMS will not modify the layer assignments in the recharge package when the Map→MODFLOW command is executed.

8 Model with Parameters

The final topic covered will be parameters in the recharge package. Information on parameters in MODFLOW models can be found in other GMS tutorials. This tutorial will focus on how parameters affect visualization of recharge in GMS.

1. Select the File | New command and select Don’t Save at the prompt.
2. Click Open to bring up the Open dialog.
3. Select “Project Files (*.gpr)” from the Files of type drop-down.
4. Browse to the Tutorials\MODFLOW\recharge directory and select “mf2k_recharge_param.gpr”.
5. Click Open to import the project and close the Open dialog.

The view will look like Figure 17 (select the Oblique View macro if needed). The MODFLOW model is transient and has multiple recharge parameters.
Figure 17  Initial view of project

1. Select the “RCH Rate” item in the Project Explorer.

The view will look like Figure 18. This shows the recharge values on the grid.

Figure 18  RCH rate contours

2. Cycle through the time steps to view the recharge at the different time steps.

3. Double-click on the “RCH” item in the Project Explorer to bring up the MODFLOW Recharge Package dialog.
Notice that the values in the spreadsheet include -3.0, -1.0, 0.0, 0.0001. However, in the view of the grid there are values between 0.0 and 0.0004. These values come from defined parameters.

4. Click OK to exit the MODFLOW Recharge Package dialog.

5. Select MODFLOW | Parameters to open the Parameters dialog.

Notice there are four recharge parameters. The values displayed on the grid come from the Value specified in this dialog. The RCH_3 parameter uses the <Pilot points> option. This means that the values shown on the grid are interpolated from an associated scatter point set.

6. Click OK to exit the Parameters dialog.

7. Right-click the “RCH Rate” item in the Project Explorer and select the Display Key Values command.

The view will change to be like Figure 19. Notice that the values displayed now include the negative numbers from the MODFLOW Recharge Package dialog. Cycle through the time steps to see the recharge parameter key values in different stress periods.

Figure 19  RCH Rate Contours of Parameter Key Values

MODFLOW supports a more complicated way to define recharge parameters using clusters. This is supported in GMS but it can not be visualized. For more information about these types of parameters see the tutorial “MODFLOW – Advanced Parameter Options”.

9 Conclusion

This concludes the “MODFLOW – Recharge” tutorial. The following key topics were discussed and demonstrated:

- Recharge package inputs.
- How to visualize the data in the Recharge Package.
- The effect of IBOUND on recharge.
- The effect of the specified layer option on recharge.
- How the Map→MODFLOW command works with recharge.
- How parameters affect the display of recharge.