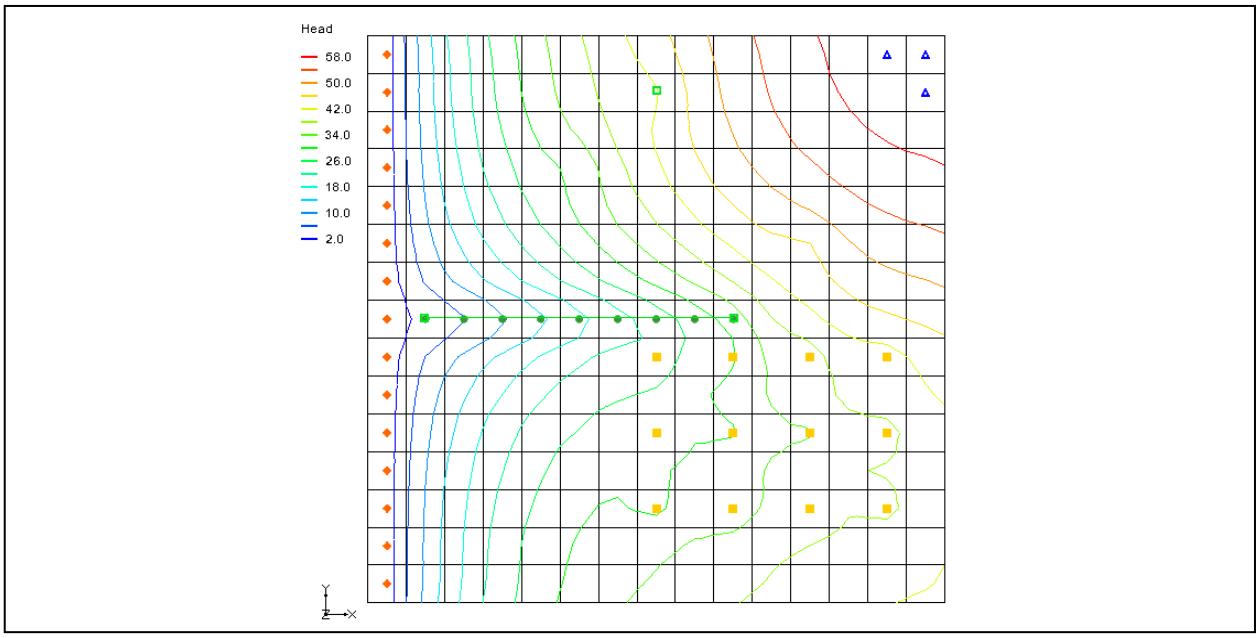
*GMS 10.0 Tutorial*

# *MODFLOW – DRT Package*

The MODFLOW drain return package




## Objectives

Learn the MODFLOW drain return package (DRT) interface in GMS and compare the package to the regular MODFLOW drain (DRN) package.

## Prerequisite Tutorials

- MODFLOW – Conceptual Model Approach I

## Required Components

- Map Module
- Grid Module
- MODFLOW

## Time

- 25-40 minutes

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# 1 Introduction

In MODFLOW, drain boundary conditions are used to simulate water leaving the groundwater system. MODFLOW has two standard packages that are used to model drains: the DRN (Drain) package and the DRT (Drain Return) package. The Drain Return package can be used to simulate the return flow of water discharged from a drain boundary condition to the groundwater system. GMS has long supported the DRN package, and starting at version 7.0, GMS supports the DRT package.

The DRN package has existed since the first MODFLOW release. Each drain boundary condition requires the user to specify a drain elevation and a drain conductance. When the simulated head in a cell is above the drain elevation, then water will leave the groundwater system proportional to the drain conductance. When the simulated head in a cell is less than the drain elevation, then no water leaves the system through the drain boundary condition.

The DRT package was introduced with MODFLOW 2000. In addition to specifying a drain elevation and conductance, the user may specify a return flow cell and a return flow factor (0.0-1.0). A portion of the water that would normally leave the groundwater system through the drain is returned to the model at the return flow cell. Figure 1 illustrates an example of where a DRT boundary condition may be used.

 

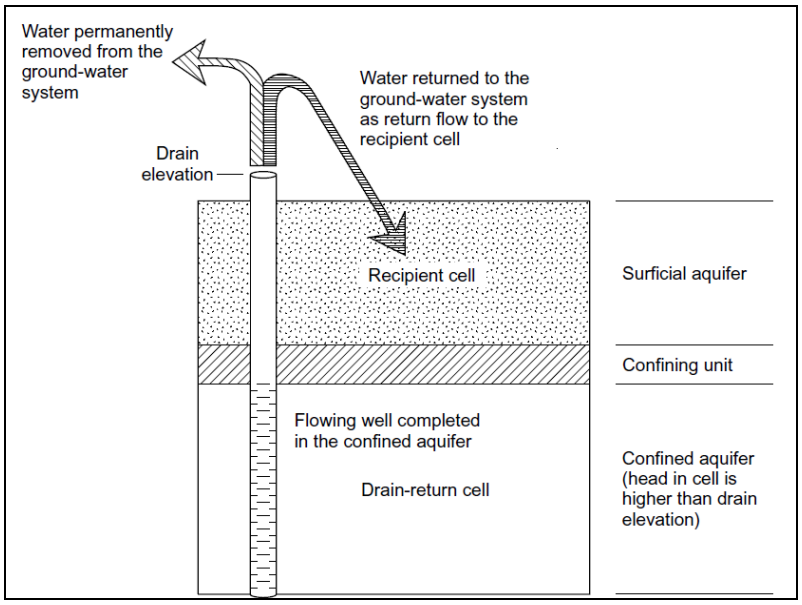


*Figure 1 DRT model, from Banta, 2000*[1]

This tutorial explains how to use the DRT package and compares it to the DRN package. Both packages can be used at the same time if desired.

## 1.1 Outline

Here are the steps for this tutorial:

1. Read in an existing MODFLOW simulation.
2. Change the DRN boundary conditions to DRT boundary conditions.
3. Change the DRT boundary conditions to return flow to the model.
4. Create a simple conceptual model to illustrate how DRT can be modeled conceptually and mapped to MODFLOW.

# 2 Description of Problem

The problem in this tutorial is the same as the problem in the "MODFLOW – Grid Approach" tutorial, and is shown in Figure 2. This problem is a modified version of the

1. Banta, Edward R. (2000), MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model-Documentation of Packages for Simulating Evapotranspiration with a Segmented Function (ETS1) and Drains with Return Flow (DRT1). Open-File Report 00-466, Denver, Colorado.

 

sample problem described near the end of the *MODFLOW 88 Reference Manual*. Refer to the "MODFLOW – Grid Approach" tutorial for a complete description of the problem. In brief, it is a grid-based model (no conceptual model) that has three layers, some wells, some drains, recharge, and constant head cells.

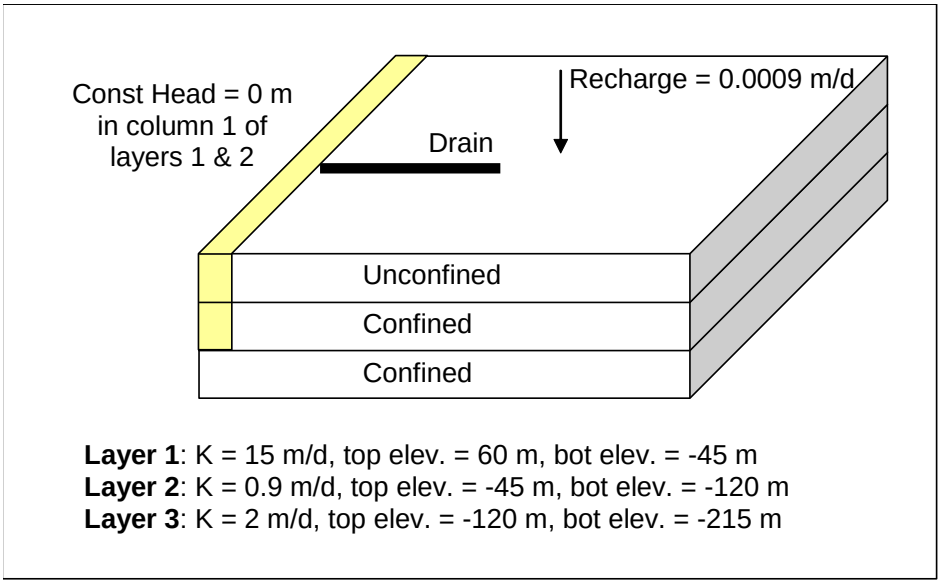


*Figure 2 Sample problem to be solved*

# 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 Open the Existing Model

This tutorial 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/drt* folder.
3. Select the "modfgrid.gpr" file.
4. Click the **Open** button.

This opens the model. The user should see a grid with head contours and symbols representing wells, drains and other boundary conditions.

 

# 5 Save 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 name to "drt."
3. Save the project by clicking the **Save** button.

# 6 Change DRN Boundary Conditions to DRT Boundary Conditions

The first change will be for the user to delete the DRN boundary conditions and create identical DRT boundary conditions.

## 6.1 Selecting the Drain Cells

It is necessary to select the cells on columns 2-10 of row 8. Do as follows to select the cells:

1. Choose the **Select Cells** tool.
2. While holding down the Shift key, select the cells with the drain boundary conditions shown as green dots in the figure below.

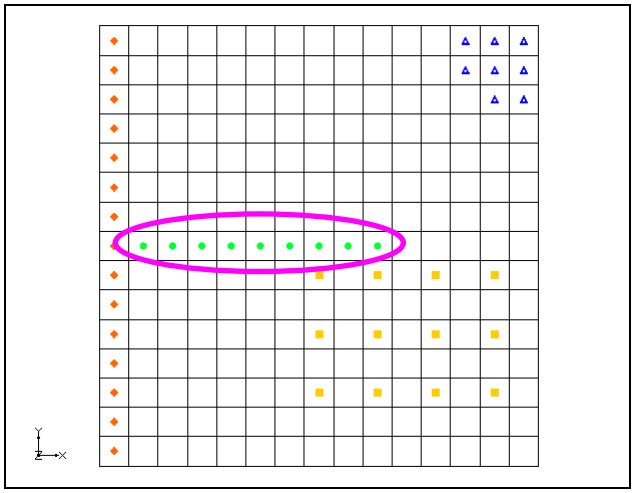

*Figure 3 Location of the drain boundary conditions*

3. Select the *MODFLOW* | *Advanced* | **Sources/Sinks** command.

This command brings up the *MODFLOW Sources/Sinks* dialog. The user will create new DRT boundary conditions and copy the properties of the existing drain boundary conditions.

## 6.2 Create DRT Boundary Conditions

1. On the left side of the dialog, select the *Drain (DRT)* item.
2. Near the bottom of the dialog select the **Add BC** button. This will create new DRT boundary conditions in each of the selected cells.
3. On the left side of the dialog, select the *Drain* item.
4. Holding down the shift button, select the *Elevation* and *Conductance* columns.
5. Right-click on the one of the selected columns and select the **Copy** command.
6. Switch back to the DRT boundary conditions by selecting the *Drain (DRT)* item.
7. Select the *Elevation* and *Conductance* columns in the spreadsheet.
8. Now right-click on any cell, and select the **Paste** command.

## 6.3 Deleting DRN Boundary Conditions

Now it is necessary to delete the drain boundary conditions.

1. Switch back to the DRN boundary conditions by selecting the *Drain* item.
2. Select the **Delete All BCs** button near the bottom of the dialog.
3. Select **OK** to exit the dialog.
4. Click anywhere outside the grid to unselect the cells.

Notice the color of the boundary conditions has changed slightly to be dark green.

# 7 Save and Run MODFLOW

The next step is to save these changes and run MODFLOW.

1. Select the **Save** button (or the *File* | **Save** menu command).
2. Select the *MODFLOW* | **Run MODFLOW** menu command.
3. When MODFLOW finishes, select the **Close** button.
4. Compare the new and old solutions by alternately selecting the "modfgrid (MODFLOW)" and the "drt (MODFLOW)" folders in the Project Explorer. (The user may need to expand the "3D Grid Data" folder and "grid" item in the Project Explorer.)

Notice the head is identical in the new "drt" solution.

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

## 8 Examine the flow budget

The user will now compare the flow budget information from the two models.

1. Select the "modfgrid (MODFLOW)" solution in the Project Explorer.
2. Select the *MODFLOW* | **Flow Budget** menu command.
3. In the *Flow Budget* dialog, notice under *Sources/Sinks* in the *Flow Out* column that, for *Drains*, the value is -136771.69 and in the *Flow In* column that, for Drains (DRT), there is no value.
4. Select **OK** to exit the dialog.
5. Now Select the "drt (MODFLOW)" solution from the Project Explorer.
6. Select the *MODFLOW* | **Flow Budget** menu command.
7. In the *Flow Budget* dialog, notice under *Sources/Sinks* in the *Flow Out* column that, for *Drains*, there is no value and that, for *Drains (DRT)*, the value is -136771.69.
8. Select **OK** to exit the dialog.

## 9 Change the Return Flow Cell for the DRT boundary Conditions

This tutorial has shown that the DRT package can be used exactly as the DRN package. Now the user will modify the DRT inputs to simulate the return flow from the drains to the groundwater system. First, it would be wise to save the model with a new name.

1. Select the *File* | **Save As** menu command.
2. Change the project name to "drt1."
3. Save the project by clicking the **Save** button.
4. Select the *MODFLOW* | *Optional Packages* | **DRT - Drain Return** menu command.
5. In the *MODFLOW Drain Return Package* dialog, enter "15" for the *Return i* and the *Return j* for each of the DRT boundary conditions.
6. Enter "0.5" for the *Return-flow proportion (Rfprop)* for each of the DRT boundary conditions.
7. Select the **OK** button to exit the dialog.

 

## 10 Save and Run MODFLOW

The next step is to save these changes and run MODFLOW.

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

The user should notice some changes in the new solution.

4. Compare the new and old solutions by alternately selecting the "drt (MODFLOW)" folder and the "drt1 (MODFLOW)" folder in the Project Explorer.

Notice the head is different in the new "drt1" solution.

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

## 11 Examine the Flow Budget

The next step is to view the flow budget information from the "drt1" model

1. Select the "drt1 (MODFLOW)" solution in the Project Explorer.
2. Select the *MODFLOW* | **Flow Budget** menu command.
3. In the *Flow Budget* dialog, notice under *Sources/Sinks* that, for *Drains (DRT),* there are values for both *Flow In* and *Flow Out.*
4. Select **OK** to exit the dialog.

## 12 Creating a Conceptual Model

Before changing the model to use a conceptual model, the next step is to save the model with a new name.

1. Select the *File* | **Save As** menu command.
2. Change the project name to "drt2," and select the **Save** button.

The next step is to examine how to use a conceptual model with DRT data.

## 12.1 Create the Conceptual Model

1. Right-click in the Project Explorer and select the *New* | **Conceptual Model** command from the pop-up menu.
2. In the *Conceptual Model Properties* dialog, change the *Name* to "modfgrid."
3. Click **OK**.

## 12.2 Create a Coverage

1. Right-click on the "modfgrid" conceptual model that was just created in the Project Explorer.
2. Select the **New Coverage** command from the pop-up menu.
3. In the *Coverage Setup* dialog, change the *Coverage Name* to "drt."
4. In the list of *Source/Sink/Bc Type*, turn on the following options:
   - *Layer range*
   - *Drain (DRT)*
5. Click **OK** to exit the *Coverage Setup* dialog.

## 12.3 Create the DRT Arc

1. Select the **Create Arc** tool.
2. Create an arc for the drains as shown in Figure 3. Make sure the left end of the arc does not enter the specified head cell on the left side of the model.

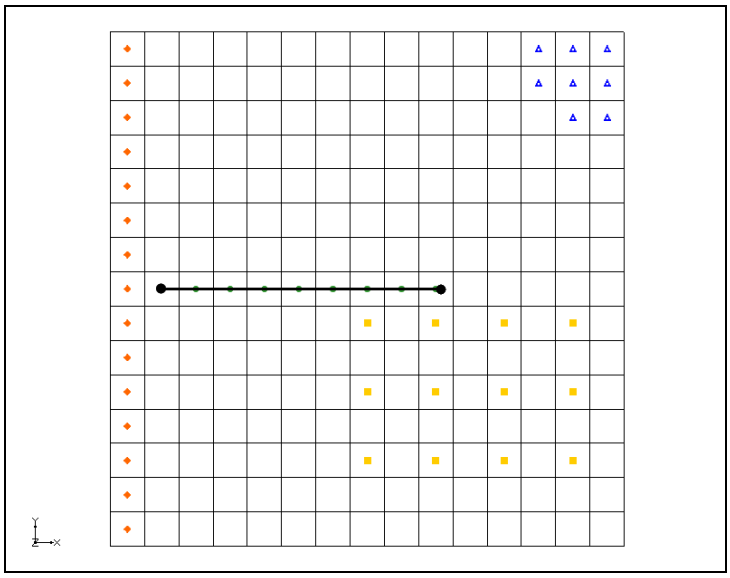

*Figure 3 Creating an arc for the drains*

3. Switch to the **Select** tool.
4. Double-click on the newly created arc.
5. In the *Attribute Table* dialog, change the *Type* to "drain (DRT)."
6. Enter "4.8" for the *Conductance*.
7. Leave the *return-flow proportion (Rfprop)* as "0.0" for this arc.
8. Select **OK** to exit the dialog.
9. Click on the right arc node.
10. Select the **Properties** button.
11. In the *Attribute Table* dialog, enter "30.0" for the *Bottom elevation*.
12. Select **OK** to exit the dialog.

The left arc node *Bottom elevation* is defaulted to zero, so it is not necessary to edit the value.

## 12.4 Create DRT Point

The user will now create a DRT point in the coverage.

1. Select the **Create Point** tool.
2. Create a point as shown in the figure below.

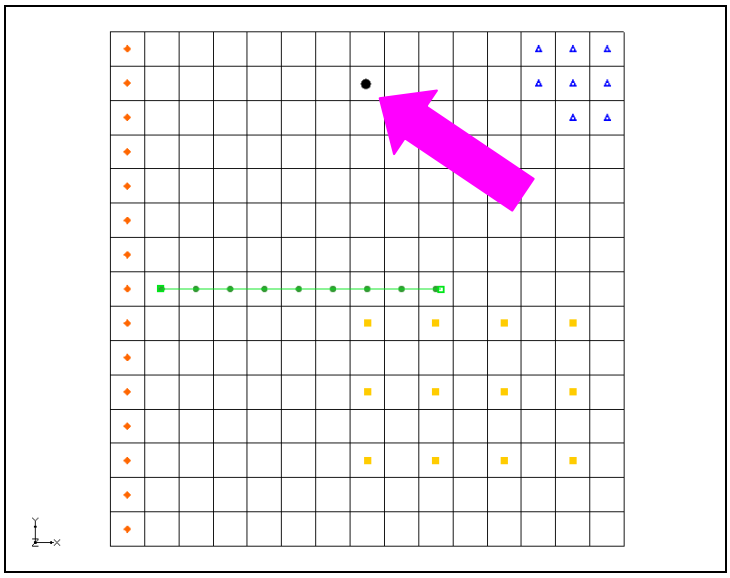

*Figure 4 New DRT point*

3. Switch to the **Select** tool.
4. Double-click on the point that was just created.
5. In the *Attribute Table* dialog, set the values to be as shown in Figure 5.

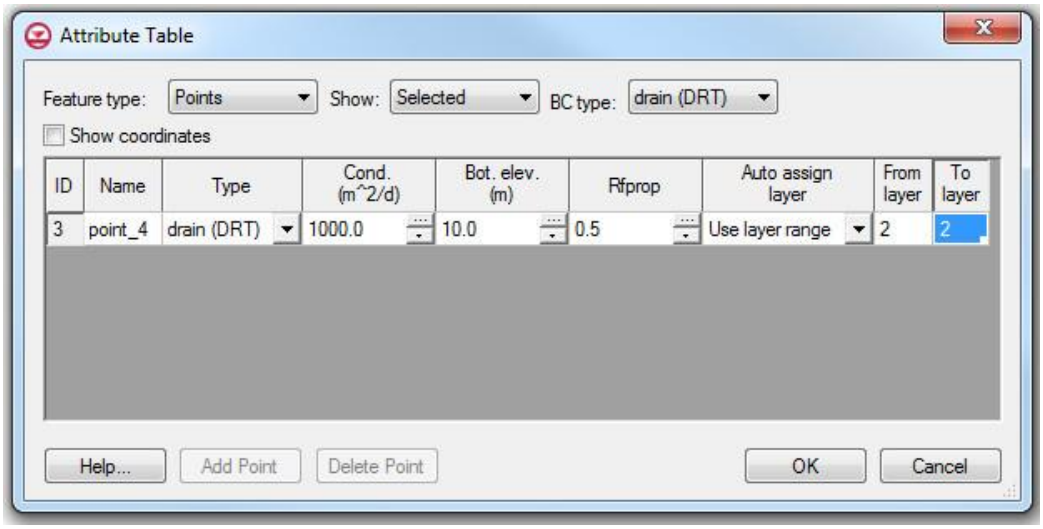


*Figure 5 Coverage Properties dialog showing the polygon*

6. Click **OK** to exit the *Attribute Table* dialog.

## 13 Map → MODFLOW

The conceptual model is now set up so it is possible to map it to the MODFLOW grid.

1. Select the *Feature Objects* | **Map→ MODFLOW** menu command.
2. When the *Map → Model* dialog appears, click **OK**.

## 14 Examine the DRT Package

Now it's time to take a look at the data in MODFLOW that was mapped from the conceptual model.

1. Select the *MODFLOW* | *Optional Packages* | **DRT - Drain Return** menu command.

Review the various DRT boundary conditions that were created. Notice that the boundary conditions created from the arc have a return-flow proportion of 0.0, while the boundary condition created from the point has the return-flow proportion of 0.5. Also, notice that the return cell location is defaulted to the same I, J location as the boundary condition except that K is set to 1. If the user changes the display at the bottom of the dialog to Display cell IJK, the user will see that the last DRT boundary condition is located at KIJ 2,8,2 and the return KIJ is 1,2,8.

2. Click **OK** to exit the *MODFLOW Drain Return Package* dialog.

## 15 Saving and Running MODFLOW

Now it is time to save these changes and run MODFLOW.

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

The user should notice some slight changes in the new solution.

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

## 16 View the Computed Flows for the Feature Objects

Since the DRT boundary conditions were created from feature objects in the map module, it is possible to select the points or arcs that were used to create the boundary conditions and view the computed flow out of the model from those boundary conditions.

1. Select "modfgrid" conceptual model in the Project Explorer.
2. Click on the DRT arc in the coverage.

Notice in the information strip at the bottom of the GMS window that the computed flow out of the model from the DRT arc is shown similar to the figure below. The user can also select the DRT point and see similar information.

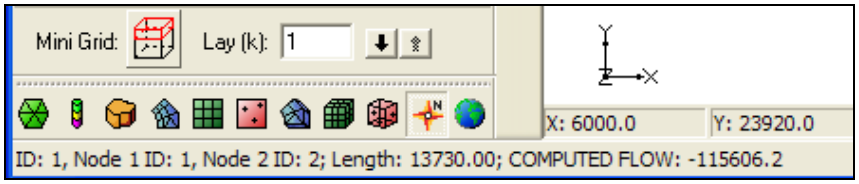


*Figure 6 Computed flow from the DRT arc*

## 17 Creating a DRT Parameter

Now the tutorial will illustrate the creation of a DRT parameter. The user will change the conductance on the DRT arc to use a parameter instead of specifying the conductance value.

1. Double-click on the DRT arc in the coverage.
2. In the *Attribute Table* dialog, change the value in the *Cond.* field to "-10.0."
3. Click **OK** to exit the dialog.
4. Select the *Feature Objects* | **Map → MODFLOW** menu command.
5. Click **OK** at the prompt.
6. Select the *MODFLOW* | **Parameters** command.
7. In the *Parameters* dialog, click the **Initialize From Model** button. Notice that a new parameter has been created.
8. Change the *Value* to "4.8."
9. Click **OK** to exit the *Parameters* dialog.
10. Select the *MODFLOW* | *Optional Packages* | **DRT - Drain Return** menu command.

Notice that the conductance is set to -10.0 for the boundary conditions created by the arc. In addition, notice that the spreadsheet now has a *Cond. factor* column. The values listed in the *Cond. factor* column are multiplied by the parameter value to give the final conductance value for the DRT boundary condition.

11. Select **OK** to exit the *Drain Return* dialog.

 

# 18 Saving and Running MODFLOW

Now it is time to save the changes and run MODFLOW.

1. Select the *File* | **Save As** menu command.
2. Change the project name to "drt3."
3. Click the **Save** button.
4. Select the *MODFLOW* | **Run MODFLOW** menu command.
5. When MODFLOW finishes, select the **Close** button.

The user should notice that the new solution is the same as the previous run.

# 19 Conclusion

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

- GMS supports both the DRN and DRT packages. Both packages can be used at the same time if desired.
- The DRT package produces the same results as the DRN package if the return flow factor is specified as zero.
- DRT data can be viewed and edited in the DRT Package dialog.
- DRT data can be defined on points, arcs, and polygons in a conceptual model.
- GMS supports DRT parameters.