GMS logo

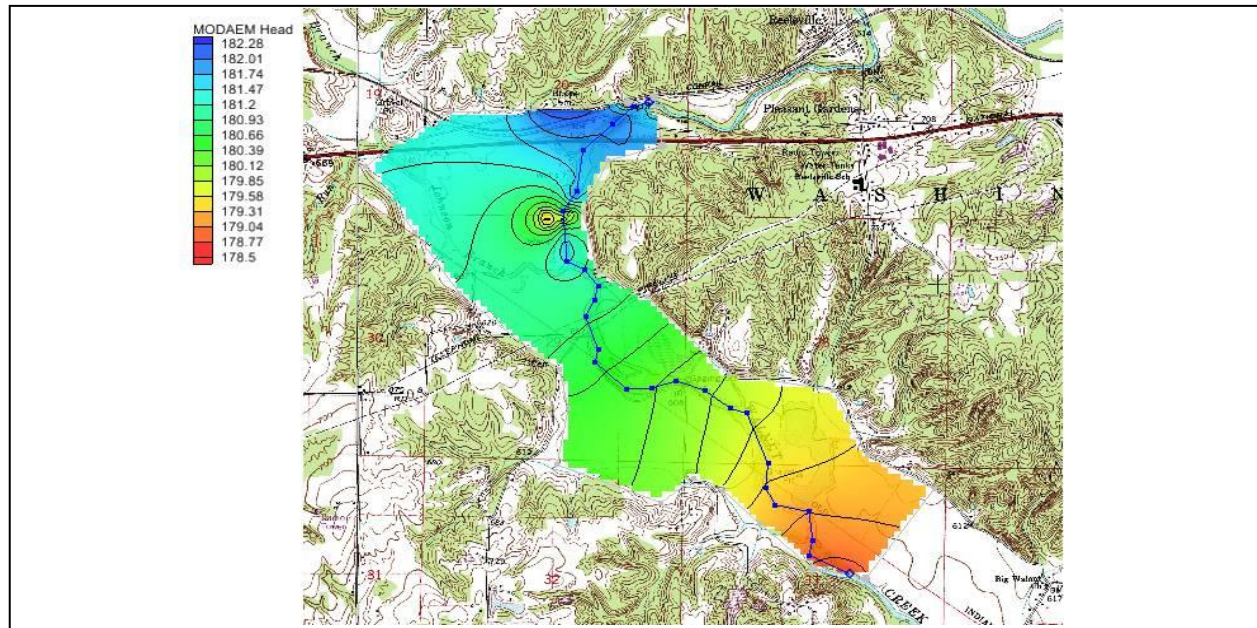*GMS 10.0 Tutorial*

MODAEM

Analytic element modeling with MODAEM

Objectives

Illustrate the use of GMS for analytic element modeling with MODAEM.

Prerequisite Tutorials	Required Components	Time
• Feature Objects	• Map Module • MODAEM	• 25-40 minutes

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1   Introduction

MODAEM is a single-layer, steady-state analytic element groundwater flow model that has been enhanced for use with GMS. This chapter introduces MODAEM to the new user and illustrates the use of GMS for analytic element modeling. This tutorial does not go into detail in explaining the analytic element method. For a more detailed explanation of analytic element modeling and MODAEM, refer to the MODAEM Help manual.

1.1   Outline

Here are the steps of this tutorial:

1. Read in a background map.

2. Create a conceptual model and define the parameters.

3. Run MODAEM for different conditions.

2   Description of Problem

This tutorial describes the use of GMS to model groundwater flow near the well field of Brazil, Indiana, USA. Brazil (population 8188) operates a well field about 5 miles east of town, in the floodplain of Big Walnut Creek (see Figure 1). The objectives of this model are to do the following:

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- Model the 5-year capture zone for the wellfield for use in the Brazil wellhead protection effort.

- Examine the effects of the addition of a well to the wellfield.

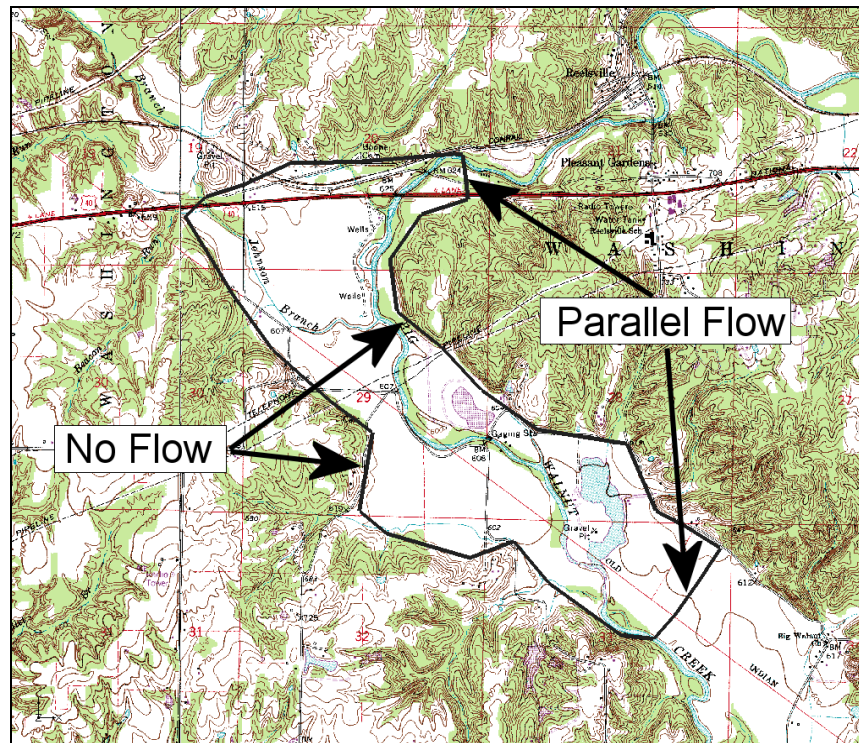The following figure shows the site location, along with the model boundaries.

Figure 1   Model boundary

2.1   Setting and Data Collection

The well field is situated in the floodplain of Big Walnut Creek. The aquifer is composed of coarse gravel with an average hydraulic conductivity of 250 ft/d (60.9 m/d), deposited in a buried bedrock valley. Although the bedrock surrounding the valley is slightly permeable, it is not considered an important source of water. The thickness of the gravel aquifer in the valley varies from 10–80 ft (3.0–24.4 m). At the wellfield, the ground elevation is roughly 600 ft (183 m), and the aquifer is roughly 60 ft (18.3 m) thick.

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   Reading in the Background Map

The first step to create the model is to read in a background image of the site being modeled. The user will use the image as a guide as he or she creates points, arcs, and polygons to define features of the model.

1. Select the **Open** 📂 button.

2. Locate and open the directory entitled *Tutorials\MODAEM\modaem.*

3. Change the *Files of type* to "Images (*.tif; *.tiff; *.jpg; *.jpeg; *.png; *.sid)."

4. Select the file "brazil_topo.jpg."

5. Click **Open.**

6. Depending on the program preferences, a prompt may appear asking if the user wants to build image pyramids. If this happens, select **No** at the prompt.

5   Defining the Units

At this point, the user can also define the units used in the conceptual model. The chosen units will be applied to edit fields in the GMS interface to remind the user of the proper units for each parameter.

1. Select the *Edit* | **Units** command to open the *Units* dialog.

2. For *Length*, select the **"…"** button next to the *Length* area to open the *Display Projection* dialog.

3. Change the *Units* to "Meters" for the Vertical units.

4. To check that meters are selected for the Horizontal units, click the **Set Projection** button next to *Global projection*.

5. In the *Select Projection* dialog, go down to the *Planar units* drop-down menu and ensure that "Meters" are selected.

6. Click **OK** to exit the *Select Projection* dialog.

7. Click **OK** to exit the *Display Projection* dialog.

8. For *Time*, select "d" (for days). Ignore the other units (they are not used for flow simulations).

9. Select the **OK** button to exit the *Units* dialog.

6   Creating the Conceptual Model

It is now possible to enter the model data. First, the user will create a MODAEM conceptual model. Then the user will create coverages to define the boundary conditions and aquifer properties. The boundary of the model is shown in Figure 2.

1. In the Project Explorer, right-click on the empty space.

2. Then, from the pop-up menu, select the *New* / **Conceptual Model** command.

3. Change the *Name* to "Indiana."

4. Change the *Type* to "MODAEM."

5. Click **OK**.

6. Right-click on the "Indiana" conceptual model.

7. Select the **New Coverage** menu command to open the *Coverage Setup* dialog.

8. Change the *Coverage name* to "Boundary."

9. Select the *Use to define model boundary* option.

10. Click **OK**.

11. Select the "Boundary" coverage.

12. Select the **Create Arc** tool.

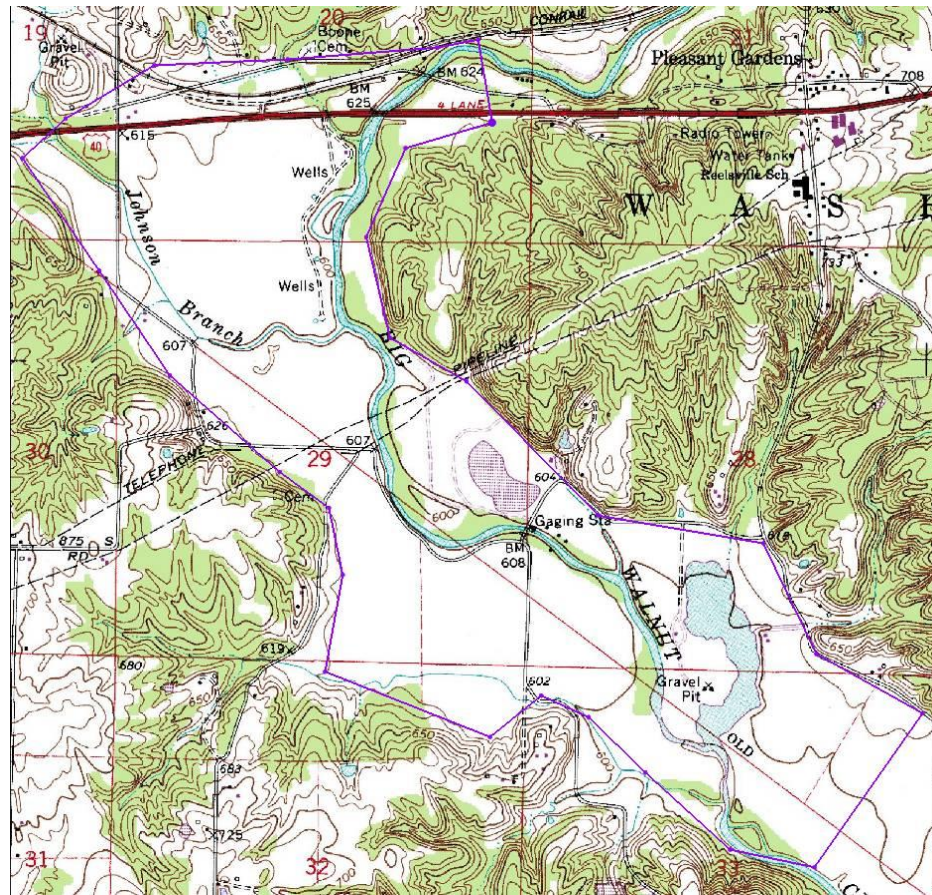13. Click out the boundary as shown in Figure 2 below.

Figure 2   Boundary arcs

7   Creating the Specified Head Arcs

By default, the arcs in a MODAEM boundary coverage are "no flow" boundaries. This means the arc's type is set to "specified flow" and that the flow is set to 0. Next, the user will add specified head arcs to this coverage. To create the specified head arcs, the user will split the boundary arc into four separate arcs.

7.1   Convert Vertices to Nodes

1. Select the **Display Options** macro.

2. On the left side of the dialog, make sure that *Map Data* is selected.

3. Turn on *Vertices*.

4. Click **OK**.

5. Select the **Select Objects** tool.

6. Select the four points (vertices and/or nodes) displayed in the figure below. To select more than one point, hold the shift key while selecting.
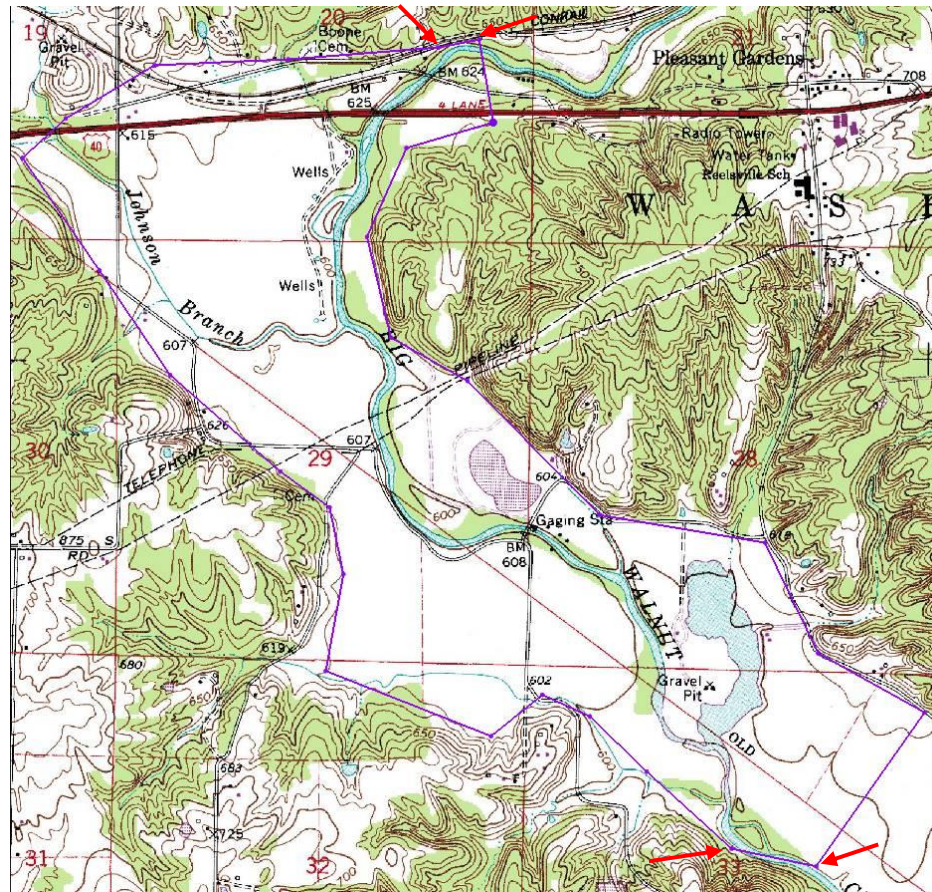

Figure 3   Convert vertices to nodes

The user may need to insert additional vertices. This can be done by using the **Create Vertex** tool. Simply select the tool and then click on the arc in the desired location. Also, depending on how the user created the boundary arc, one of the vertices shown in the figure above may actually be a node. In that case, the user will not be able to select it with the select vertex tool. If the user does have a node at one of the locations shown above, just select the other three vertices.

7. Select the *Feature Objects* / **Vertices → Nodes** command to convert all the selected vertices to nodes.

7.2   Assigning Arcs

1. Select the **Select Arcs** tool.

2. Select the two new arcs that were created on the north and south of the boundary.
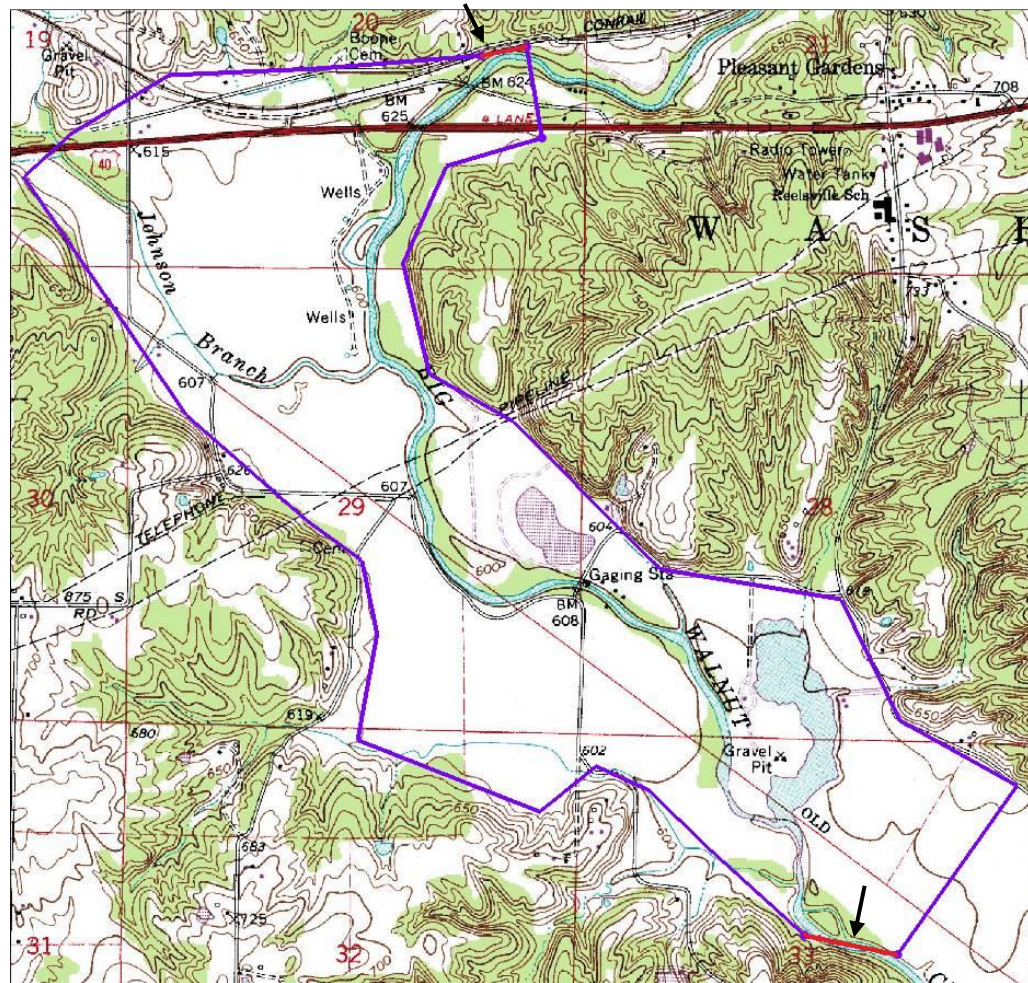
Figure 4   Specified head arcs

3. Select **Properties** 🖭 button to open the *Attribute Table* dialog.

4. In the *All* row, change the type to "spec. head."

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

6. Select the **Select Points/Nodes** 🖰 tool.

7. Select both nodes on the northern specified head arc. To select more than one node, hold the shift key down while clicking or drag a box around both nodes.

8. Select the **Properties** 🖭 button to open the *Attribute Table* dialog.

9. Change the *BC type* to "spec. head."

10. In the *Head* field for both nodes, enter "182.0."

11. Repeat steps 6–9 for the nodes attached to the southern specified head arc, but enter "178.6" for the *Head* value.

8   Entering the Aquifer Properties

Next, enter the properties of the aquifer. Aquifer properties can be assigned to individual polygons, and the user can also define properties for a "background aquifer."

1. Select the *MODAEM* / **Global Options** command to open the *MODAEM Global Options* dialog.

2. In the *Background aquifer properties* section, enter the following values:

   - "170.0" for the *Base*

   - "18.0" for the *Thickness*

   - "60.0" for the *Hyd. cond.*

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

With a boundary coverage, a single polygon must define the aquifer being modeled.

4. Select the *Feature Objects* / **Build Polygons** command.

9   Saving the Project

It is now possible to run MODAEM. With other models in GMS, like MODFLOW for example, the user must first save the changes to the project before running the model. When running MODAEM, however, the data currently in memory is written to temporary files that MODAEM reads to compute its solution. Therefore, the user doesn't have to save the changes in GMS before running MODAEM. However, it's a good idea to save the work periodically anyway, so do that now.

1. Select the *File* / **Save As** command.

2. Change the project name to "brazil."

3. Click **Save.**

Then hit the **Save** button periodically as the model is developed.

10   Running MODAEM

The user is now ready to run MODAEM. This can be done by selecting the menu command *MODAEM* / **Solve** or by hitting the *F5* key. Once this command is executed, a dialog will appear showing the output from the MODAEM model.

1. Hit the *F5* key.

2. When MODAEM is finished, select the **Close** button.

Head contours should now appear inside the boundary coverage.

3. Select the **Contours** macro to open the *Dataset Contour Options – Map – MODAEM Head* dialog.

4. Change the *Contour method* to "Color Fill and Linear."

5. Under the *Fill options* section of the dialog, change the *Transparency* value to "40."

6. Select **OK**.

11   Creating the River

Now add the river to the model.

1. Right-click on the "Indiana" conceptual model in the Project Explorer.

2. Select the **New Coverage** option to open the *Coverage Setup* dialog.

3. Change the name of the coverage to "River."

4. Under the *Source/Sink/BCs* section, toggle on the *River* option.

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

6. Select the *Create* **Arc** tool.

7. Click out the river arc starting near the northern specified head boundary and ending near the southern specified head boundary, as shown in Figure 5 below. Don't extend the river beyond the boundary coverage.
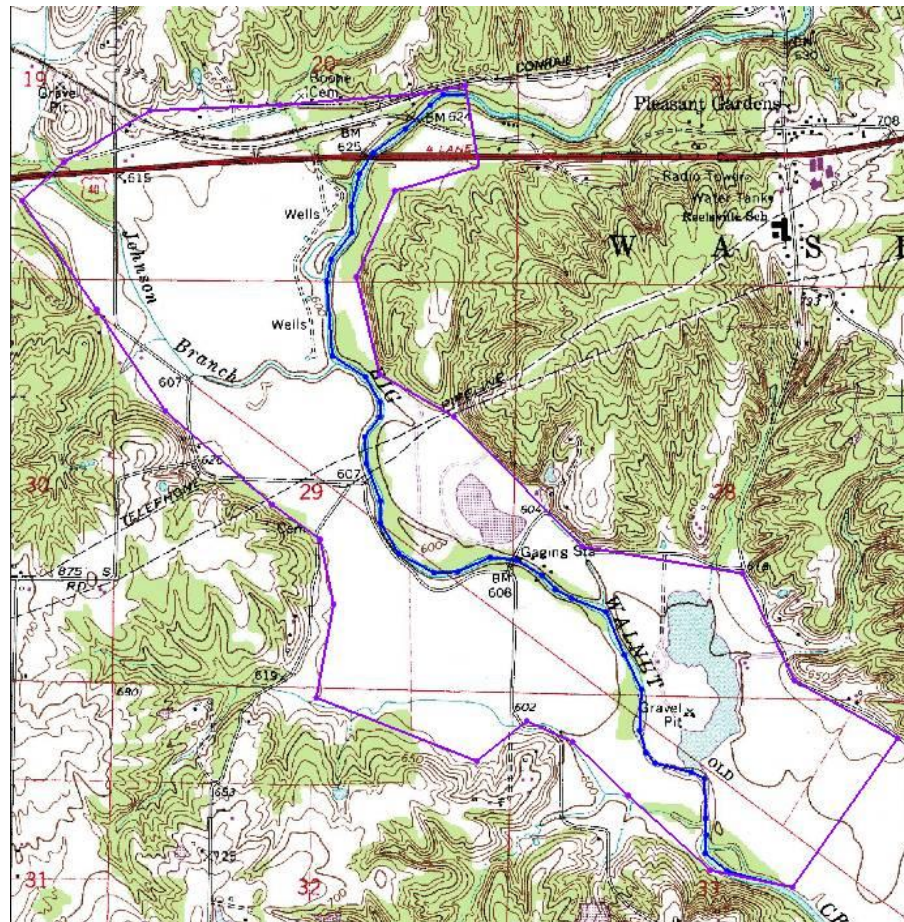
Figure 5   Modeling the river

8. Select the **Select Arcs** tool.

9. Click anywhere on the river arc to select it.

10. Select **Properties** button to open the *Attribute Table* dialog.

11. Change the type of the arc to "river."

12. Enter a value of "5000.0" for the *Cond.* (conductance).

13. Click *OK*.

14. Select the **Select Points/Nodes** tool.

15. Double-click on the river node at the northern end of the model to open the *Attribute Table* dialog.

16. Enter "182.0" for the *Head.*

17. Enter "179.0" for the *Elev*.

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

19. Repeat the same process for the southern river node (steps 14–17), but enter "178.6" for the *Head* and "175.6" for the *Elev*.

12   Running MODAEM

It is now possible to run MODAEM again.

1. Hit the *F5* key.

2. When MODAEM is finished, select the **Close** button.

The user should notice some change in the head contours, particularly around the river arc.

13   Adding Recharge

Now the user will add recharge to the model.

1. Right-click on the "Boundary" coverage.

2. Select the **Duplicate** command.

3. Double-click on the new coverage (called "Copy of Boundary") to bring up the *Coverage Setup* dialog.

4. Change the *Coverage Name* to "Recharge."

5. In the *Sources/Sinks/BCs* section of the dialog, toggle off *Specified Head* and *Specified Flow*.

6. In the *Areal Properties* section of the dialog, toggle on *Recharge*.

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

8. Select the **Select Polygons** tool.

9. Double-click on the polygon to open the *Attribute Table* dialog.

10. Assign a value of ".00042" to the *Recharge* field.

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

14   Running MODAEM

It is now possible to run MODAEM again.

1. Hit the *F5* key.

2. When MODAEM is finished, select the **Close** button.

15   Production Wells

Now the user will import production wells from a tab-delimited text file.

1. Right-click on **Indiana** 🥞 in the Project Explorer.

2. Select the **New Coverage** option to open the *Coverage Setup* dialog.

3. Change the name of the coverage to "Wells."

4. Under the *Source/Sink/BCs* section, toggle on the *Wells* option.

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

6. Select the **Open** 📂 button.

7. Locate and open the directory entitled *Tutorials\modaem*.

8. Change the *Files of type* to "All Files (*.*)."

9. Select the file "prod_wells.txt."

10. Click **Open.**

11. Toggle on the *Heading row* toggle.

12. Click the **Next** button.

13. Change the *GMS data type* to "Well data."

14. In the *File preview* section of the dialog, change the following values:

- The *Type* of the first column to "X"

- The *Type* of the second column to "Y"

- The *Type* of the third column to "Flow Rate"

15. Select the **Finish** button to exit the dialog.

The user may have difficulty seeing the wells. The well symbol can be changed in the *Display Options* dialog by clicking on the **Display** 🔵 macro and then changing the color of the symbol for *Well* in the *Coverage* section.

16   Observation Wells

Before running MODAEM again, the user will also read in field-measured head values.

1. Right-click on "Indiana" 🔶 in the Project Explorer.

2. Select the **New Coverage** option to open the *Coverage Setup* dialog.

3. Change the name of the coverage to "Observation."

4. Under the *Observation Points* section, toggle on the *Head* option.

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

6. Select the **Open** 📂 button.

7. Locate and open the directory entitled *Tutorials\modaem*.

8. Select the file "well_head.txt."

9. Click **Open.**

10. Toggle on the *Heading row* toggle.

11. Click the **Next** button.

12. Change the *GMS data type* to "Observation data."

13. In the *File preview* section of the dialog, change the following values:

    - *Type* of the first column to "Name"

    - *Type* of the second column to "X"

    - *Type* of the third column to "Y"

    - *Type* of the fourth column to "Obs. Head"

14. Select the **Finish** button to exit the dialog.

15. The user should now see observation targets appear.

17   Running MODAEM

The user is now ready to run MODAEM again.

1. Hit the *F5* key.

2. When MODAEM is finished, select the **Close** button.

18   Conclusion

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

*   MODAEM is an analytic element model, and it uses points, arcs, and polygons to compute solutions.

*   The Map module is used to construct conceptual models using feature objects (points, arcs and polygons).

*   Feature objects are grouped into coverages. Only one coverage can be active, and only the active coverage can be edited.