ARC HYDRO GROUNDWATER TUTORIALS

Working with MODFLOW Models – Steady State

Arc Hydro Groundwater (AHGW) is a geodatabase design for representing groundwater datasets within ArcGIS. The data model helps to archive, display, and analyze multidimensional groundwater data, and includes several components to represent different types of datasets, including representations of aquifers and wells/boreholes, 3D hydrogeologic models, temporal information, and data from simulation models. The *Arc Hydro Groundwater Tools* help to import, edit, and manage groundwater data stored in an AHGW geodatabase. The *MODFLOW Analyst* is a subset of the AHGW Tools that is used to manage groundwater simulation models based on the MODFLOW code developed by the United States Geologic Survey. In this tutorial we will review the MODFLOW Data Model, learn how to import steady state MODFLOW models, and create map layers from the MODFLOW data.

Tools for building and editing MODFLOW models using features are available, and are demonstrated in a separate tutorial. Currently, MODFLOW Analyst tools support models in MODFLOW 2000 and 2005 format. If you have a different version you can use the USGS utilities to convert your model to MODFLOW 2000 or 2005 formats.

1.1 Background

For this tutorial we will be working with a model of the Cache Valley in northern Utah, corresponding to the location shown in Figure 1. There are two versions of the Cache Valley model: steady state and transient. In this tutorial we will be working with the steady state version of the model. In a subsequent tutorial, we will import and explore the transient version. The model has 6 layers, 82 rows, and 39 columns.

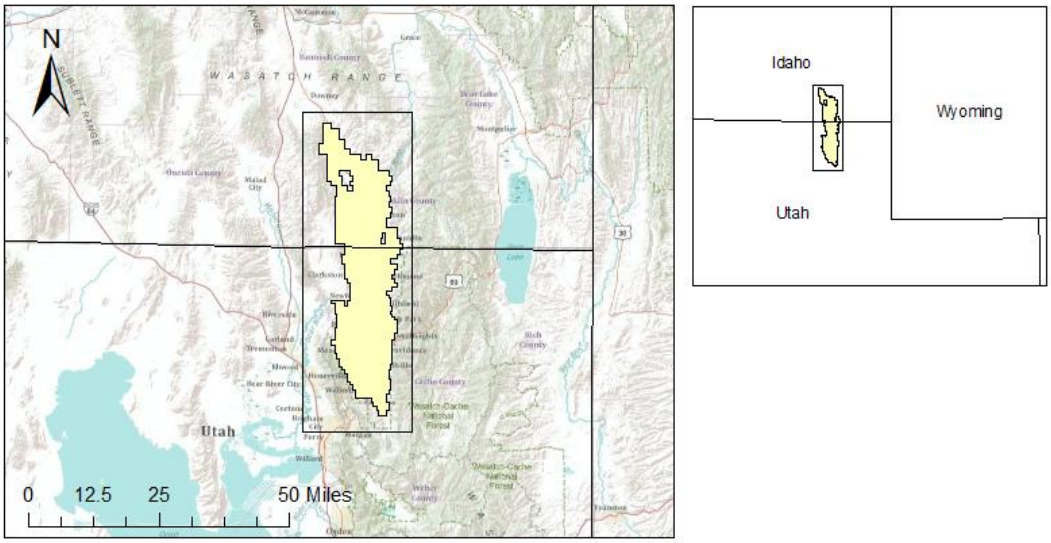


Figure 1 Location of the Cache Valley model.

1.2 Outline

The objective of this tutorial is to introduce the basic components and features of MODFLOW Analyst. We will complete the following tasks:

1. Review the structure of the MODFLOW Data Model.
2. Import a set of MODFLOW files into ArcGIS.
3. Browse the data in the resulting MODFLOW tables.
4. Generate map layers illustrating array-based MODFLOW data.
5. Generate map layers illustrating list-based MODFLOW stress package data.
6. Import and display a set of MODFLOW solution files.

1.3 Required Modules/Interfaces

You will need the following components enabled in order to complete this tutorial:

- Arc View license (or ArcEditor\ArcInfo)
- 3D Analyst
- Arc Hydro Groundwater Tools
- AHGW Tutorial Files

The AHGW Tools require that you have a compatible ArcGIS service pack installed. You may wish to check the AHGW Tools documentation to find the appropriate service pack for your version of the tools. *3D Analyst* is required for the last section of the tutorial for visualizing 3D features. If you do not have *3D Analyst*, you can skip these parts of the tutorial. The tutorial files should be downloaded to your computer and saved on a local drive.

2 Getting Started

Before opening our map, let's ensure that the Arc Hydro and AHGW Tools are correctly configured.

1. If necessary, launch *ArcMap*.

2. If necessary, open the *ArcToolbox* window by clicking on the *ArcToolbox* icon  .

3. Make sure the Arc Hydro Groundwater Toolbox is loaded. If it is not, add the toolbox by right-clicking anywhere in the *ArcToolbox* window and selecting the *Add Toolbox…* command. Browse to the top level of the *Catalog* and then browse down to the *Toolboxes*|*System Toolboxes* directory. Select the toolbox and select the *Open* button.

4. Expand the *Arc Hydro Groundwater Tools* item and then expand the *MODFLOW Analyst* toolset to expose the tools we will be using in this tutorial.

We will also be using the *MODFLOW Analyst Toolbar*. The toolbar contains additional user interface components not available in the toolbox. If the toolbar is not visible, do the following:

5. Right-click on any visible toolbar and select the *MODFLOW Analyst Toolbar* item.

When using geoprocessing tools you can set the tools to overwrite outputs by default. To set this option:

6. Open ArcMap/ArcCatalog (if not already open)

7. Select the *Geoprocessing* | *Options...* command.

8. Activate the option: "*Overwrite the outputs of geoprocessing operations*" as shown in Figure 2.

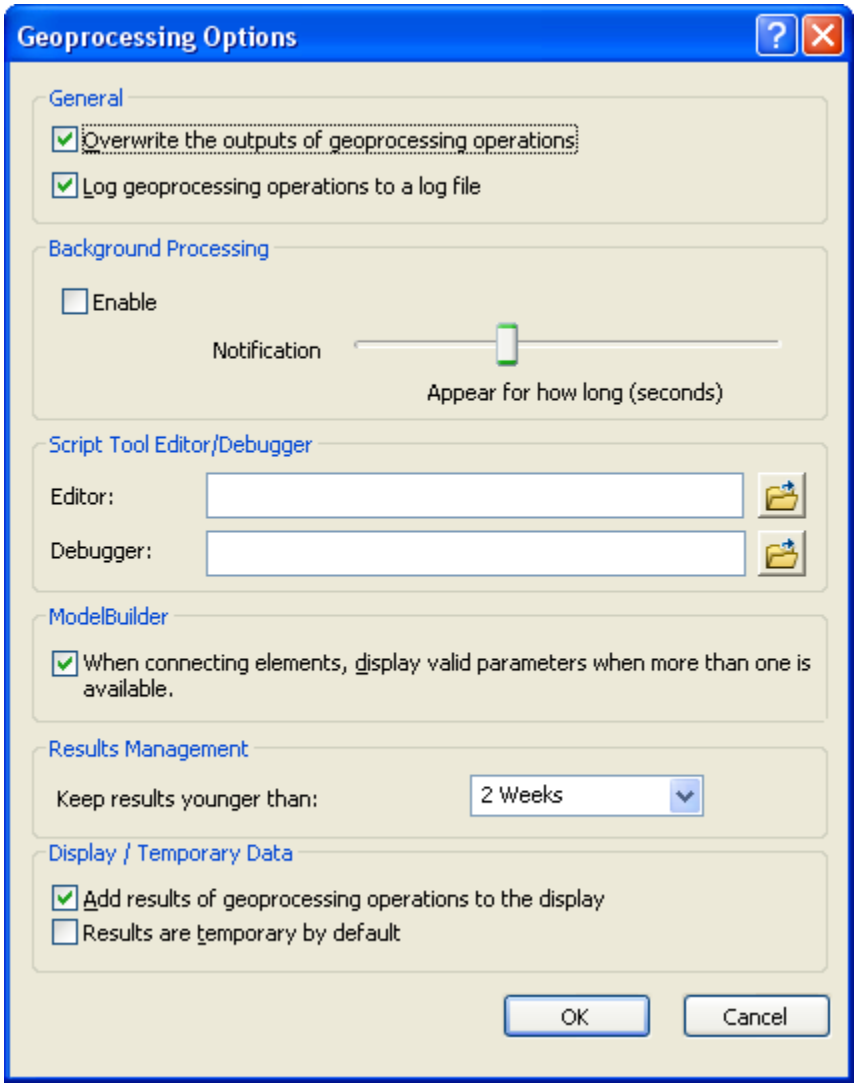


Figure 2 Setting geoprocessing tools to overwrite outputs by default.

3 Opening the Map

We will begin by importing a map containing some background data for the Cache model.

1. Select the *File*| *Open* command and browse to the location on your local drive where you have saved the AHGW tutorials. Browse to the *modflow analyst/steady state* folder and open the file entitled **cache_ss.mxd.**

Once the file has loaded you will see a map of Cache Valley in Utah. The file contains a map layer representing the states in the region. These features will not be used in the tutorial but are included to provide some context for the MODFLOW model.

4 The MODFLOW Data Model

Before importing the MODFLOW files, it is helpful to review the data model we will be using. The *MODFLOW Data Model* (MDM) is an extension to the *Simulation Feature Dataset* of AHGW (Figure 3). The Simulation feature dataset includes five feature classes: *Boundary*, *Cell2D*, *Node2D*, *Cell3D*, and *Node3D*. Boundary is a polygon feature class that defines the location of the MODFLOW grid in real world coordinates. The Cell2D feature class consists of polygons and is used to represent grid cells associated with two-dimensional simulation models or a single layer of a three-dimensional model. The Cell3D feature class consists of multipatch objects and is used to represent three-dimensional cells (primarily for visualization in ArcScene). The Node2D feature class consists of point features located at the centers of the Cell2D features and the Node3D feature class consists of 3D point features located at the centers of Cell3D features. The CellIndex table will be described below.

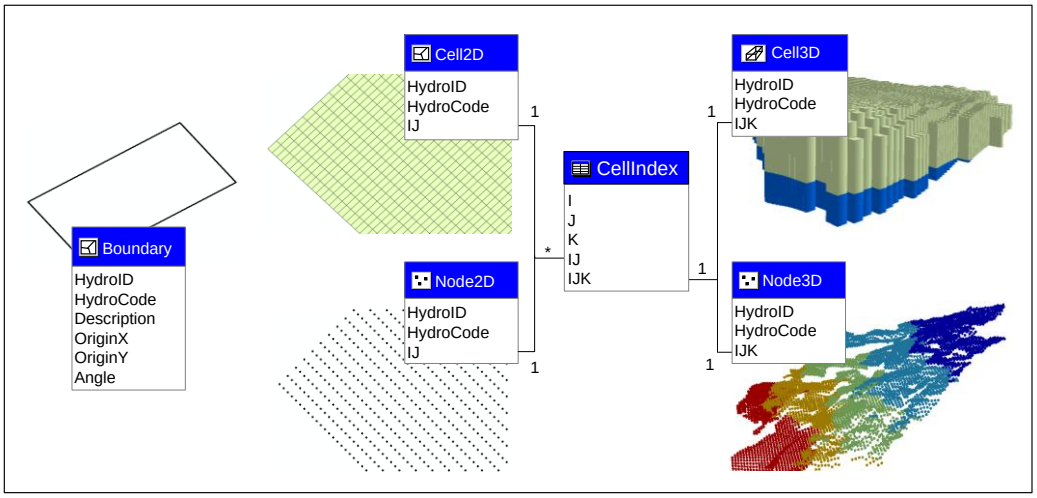


Figure 3 Simulation feature dataset.

The MODFLOW Data Model is built on top of the Simulation feature dataset and it consists of a series of tables and relationships that can be used to store an entire MODFLOW simulation within an ArcGIS geodatabase. For example, the tables associated with the Recharge (RCH) package are shown in Figure 4 and the tables associated with selected list-based stress packages (River, Well, Drain, etc.) are shown in Figure 5. The design for the entire MODFLOW Data Model can be viewed at www.archydrogw.com.

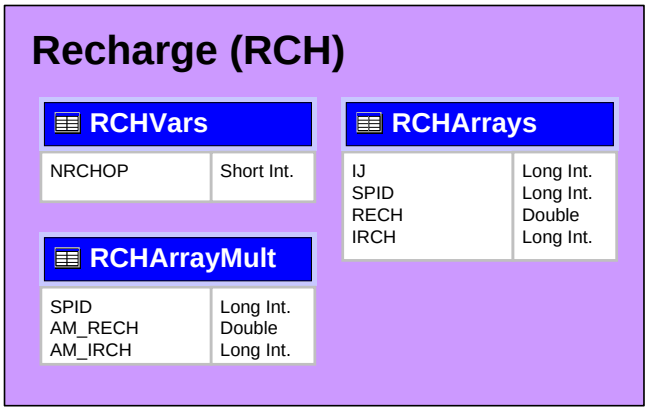


Figure 4 Tables for the Recharge package.

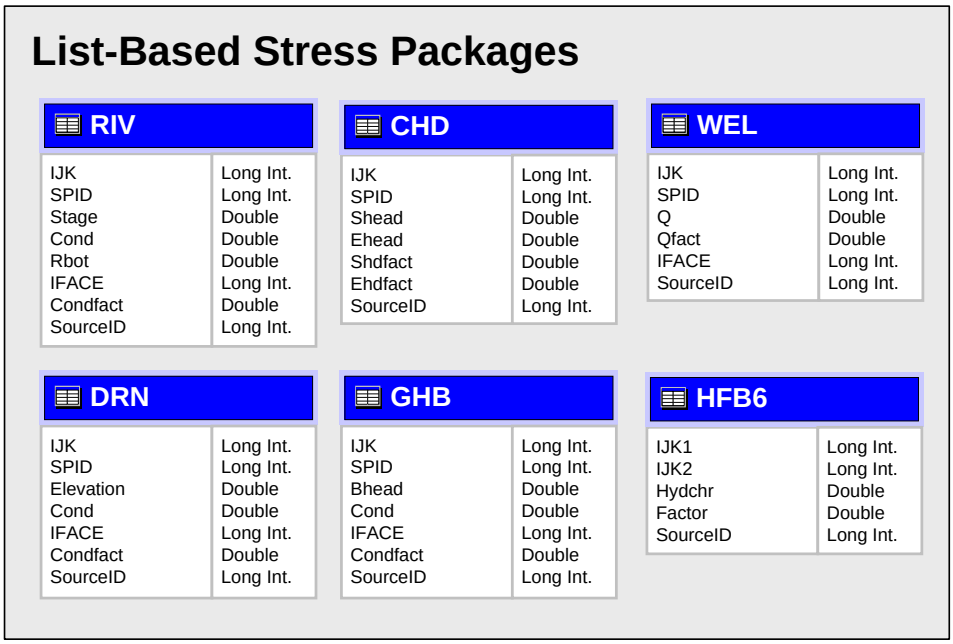
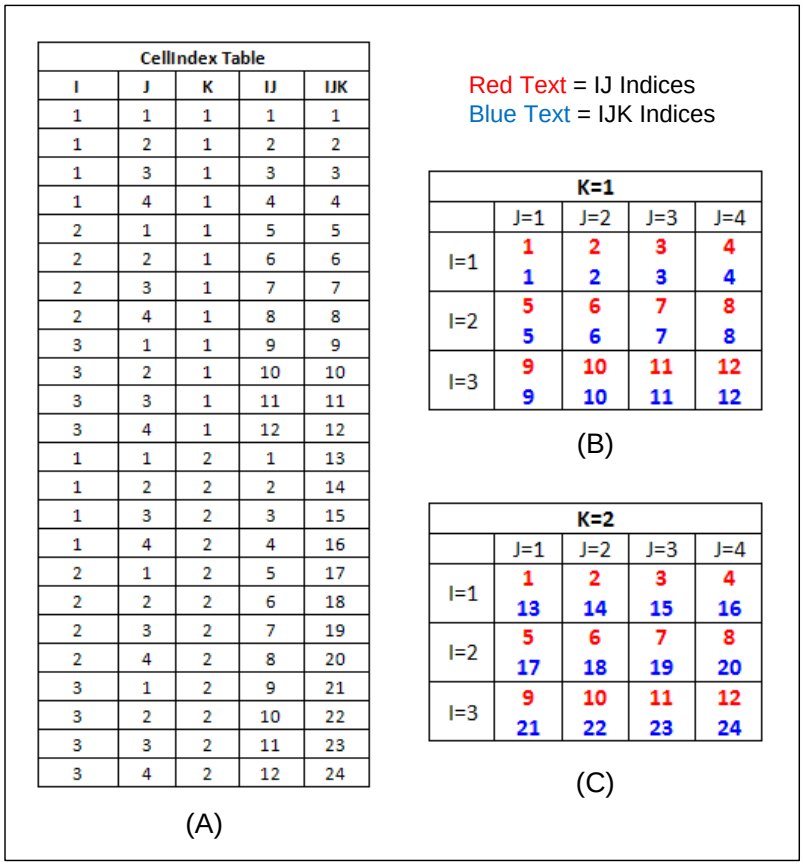


Figure 5 Tables for the List-Based stress packages.

In the MODFLOW input files, cells are identified by a combination of three integers representing the row, column, and layer indices of the cell (I, J, K). Since joins can only be accomplished using a single field, it is necessary to generate an integer field corresponding to a unique IJK combination. Furthermore, some MODFLOW input arrays are fundamentally 2D in nature (Evapotranspiration, Recharge, etc.) and require an integer identifier corresponding to a unique IJ combination. To facilitate joins and queries related to the MODFLOW data, the MDM includes a **CellIndex** table that relates I, J, and K fields to unique IJ and IJK identifiers. The contents of a CellIndex table for a MODFLOW grid with three rows, four columns, and two layers is shown in Figure 6a. The same IJ and IJK indices are organized on a layer-by-layer basis in Figure 6b and 6c. The IJ and IJK fields of the CellIndex table are populated from the I,J,K values by starting at a value of one for the cell corresponding to I=1, J=1, K=1, and looping through the cells in the grid

row-by-row within each layer, and incrementing the index. The IJ index ordering is repeated within each layer.



CellIndex Table

I	J	K	IJ	IJK
1	1	1	1	1
1	2	1	2	2
1	3	1	3	3
1	4	1	4	4
2	1	1	5	5
2	2	1	6	6
2	3	1	7	7
2	4	1	8	8
3	1	1	9	9
3	2	1	10	10
3	3	1	11	11
3	4	1	12	12
1	1	2	1	13
1	2	2	2	14
1	3	2	3	15
1	4	2	4	16
2	1	2	5	17
2	2	2	6	18
2	3	2	7	19
2	4	2	8	20
3	1	2	9	21
3	2	2	10	22
3	3	2	11	23
3	4	2	12	24

(A)

Red Text = IJ Indices
Blue Text = IJK Indices

K=1

	J=1	J=2	J=3	J=4
I=1	1 1	2 2	3 3	4 4
I=2	5 5	6 6	7 7	8 8
I=3	9 9	10 10	11 11	12 12

(B)

K=2

	J=1	J=2	J=3	J=4
I=1	1 13	2 14	3 15	4 16
I=2	5 17	6 18	7 19	8 20
I=3	9 21	10 22	11 23	12 24

(C)

Figure 6 Example of a CellIndex table for a grid with 3 rows (I=3), 4 columns (J =4) and 2 layers (K=2).

The Cell2D and Node2D features include an IJ field and the Cell3D and Node3D features include an IJK field where the IJ and IJK fields are populated using the same strategy used to populate the CellIndex table. The tables in the MDM containing cell-by-cell data include either an IJ or IJK field depending on whether it is a 2D array or a 3D array. The MODFLOW tables can then be joined to the cell and node features using the CellIndex table (this process will be illustrated later in the tutorial). For example, a map layer illustrating river cells with point features could be generated by first joining the IJK field of the RIV table to the IJK field of the CellIndex table. The CellIndex.IJ field of the resulting temporary table would then be joined to the IJ field of the Node2D feature class. The values associated with individual grid layers in the resulting map layer can be displayed using a definition query ("CellIndex.K = 1, CellIndex.K=2, etc.). For 2D arrays or for models with only one grid layer, the CellIndex table can be bypassed and the IJ or IJK field of the MODFLOW tables can be joined directly with the IJ field of the Node2D and Cell2D features since the IJ and IJK values are identical for K=1. Similarly, joins can be performed directly between IJK-based tables and the Cell3D and/or Node3D features. Map layers of MODFLOW data associated with cell and node features can be symbolized and toggled on/off independently from other features in the TOC window in ArcMap and ArcScene.

5 Importing MODFLOW Files

We are now ready to import MODFLOW files into the geodatabase. Since the MODFLOW input is divided into a series of files, a typical MODFLOW simulation consists of 10-20 files. A MODFLOW simulation is imported into ArcGIS in a process that consists of the following steps:

1. The **Import MODFLOW Tables** tool is used to read the MODFLOW files, and load the data from the files into the MDM tables inside a geodatabase. This tool uses a modified version of MODFLOW that reads the files and builds the table using the ArcObjects library. Thus, it will work on any MODFLOW simulation that can be read by MODFLOW.

Tip: Currently, MODFLOW Analyst reads files in MODFLOW 2000 and 2005 format. If your files are in an earlier format, you may wish to use one of the converter utilities that can be downloaded from the USGS website.

2. The **DIS to Boundary** tool reads information related to the grid geometry from the tables associated with the DIS file and builds a Boundary polygon. The input to this tool includes the coordinates of the IJ origin of the MODFLOW grid and the angle of rotation as shown in Figure 7. This information is necessary to ensure that the MODFLOW model is imported at the proper location in world coordinate space. The origin coordinates should be in the same units as the coordinate system associated with the *modflow* Feature Dataset created previously.

3. The **Create MODFLOW Cell2D** tool takes the grid discretization information in the DIS tables and the Boundary polygon as input and creates Cell2D features.

4. The **Create MODFLOW Node2D** tool takes Cell2D features as input and creates Node2D features.

5. The **Create Cell Index Table** tool takes the DIS tables as input and creates the CellIndex table.

6. Optionally, the **Create MODFLOW Cell3D** and the **Create MODFLOW Node3D** tools can be used to create 3D features for use in ArcScene.

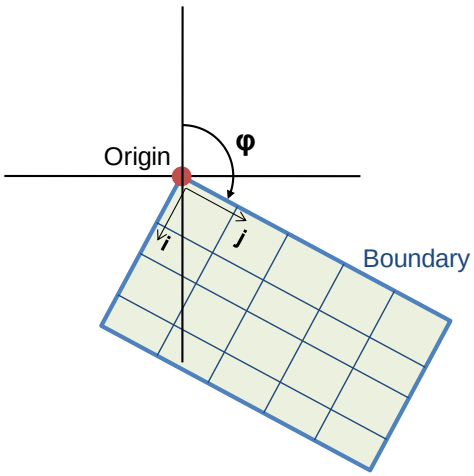


Figure 7 Grid origin and angle of rotation used to define the spatial orientation of a MODFLOW Simulation.

In order to simplify this process, the workflow (steps 1-5) has been built into a single geoprocessing tool called *Import Georeferenced MODFLOW Model*. We will use this tool to import the steady state Cache Valley model. One of the inputs for the tool is a MODFLOW world file (.mwf) which contains information on the model origin, rotation, and the spatial reference used to georeference the model. Thus, the workflow consists of two steps:

I. Create a MODFLOW world file.

II. Import the MODFLOW model using the world file.

To create the MODFLOW world file:

1. Double-click on the ***Create MODFLOW World File*** **tool** located in the *MODFLOW Analyst* | *Import* toolset.

2. Enter the following for the origin coordinates:

   Origin X: **1334103.5938334**

   Origin Y: **15392493.413323**

   Angle of Rotation: **90**

3. For the spatial reference select the Import option and browse to the **Background.mdb/Background** feature dataset.

4. Specify the output MODFLOW world file location in the **"steady state"** directory and name it **world_file.mfw**.

The tool should be populated as shown in Figure 8.

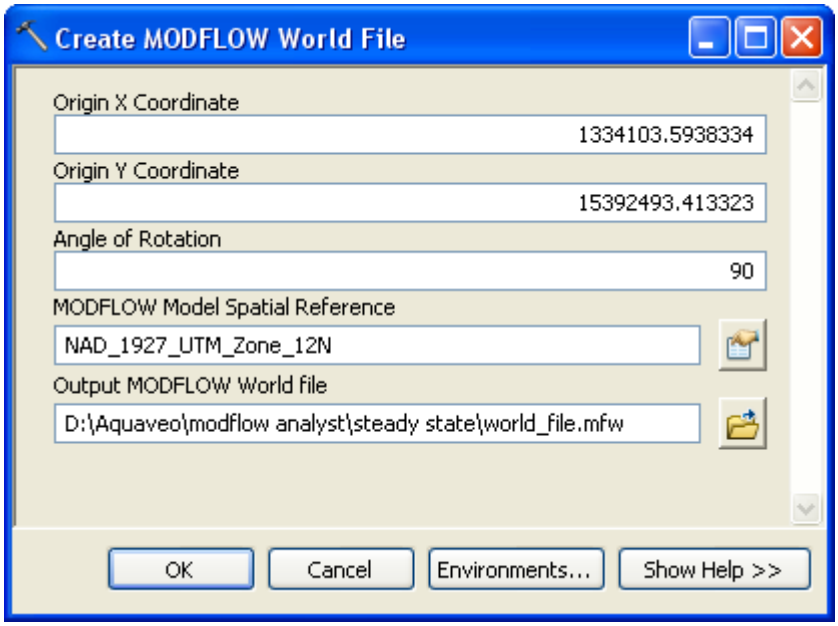


Figure 8 Parameters for the Create MODFLOW World File tool.

5. Select the *OK* button to execute the tool.

6. Select the *Close* button when the tool has finished.

Once the tool is run two new text files are created (you can view the content of the files with any text editor):

- **world_file.mfw** - contains the grid origin and the angle of rotation and a reference to a text file containing the projection information.

- **world_file.prj** – a text file containing the projection information.

To import the MODFLOW model:

7. Double-click on the ***Import Georeferenced MODFLOW Model* tool** located in the *MODFLOW Analyst|Import* toolset.

8. The path to the MODFLOW Analyst MF2K executable should automatically be populated (the executable is in Arc hydro Groundwater tools installation folder).

   Tip – when importing MODFLOW 2005 models you need to specify the appropriate executable for MODFLOW 2005 (mf2k5_ahgw.exe).

9. Specify the **cache_ss.mfn** MODFLOW name file located in the **Out_Mf2k** folder.

10. Specify the MODFLOW world file (.mfw) you created in the previous steps.

11. Select the **steady state** folder as the geodatabase location (the tool will create a new geodatabase in this folder).

12. Specify **Cache_SS_MODFLOW** for the geodatabase name.

The tool should be populated as shown in Figure 9:

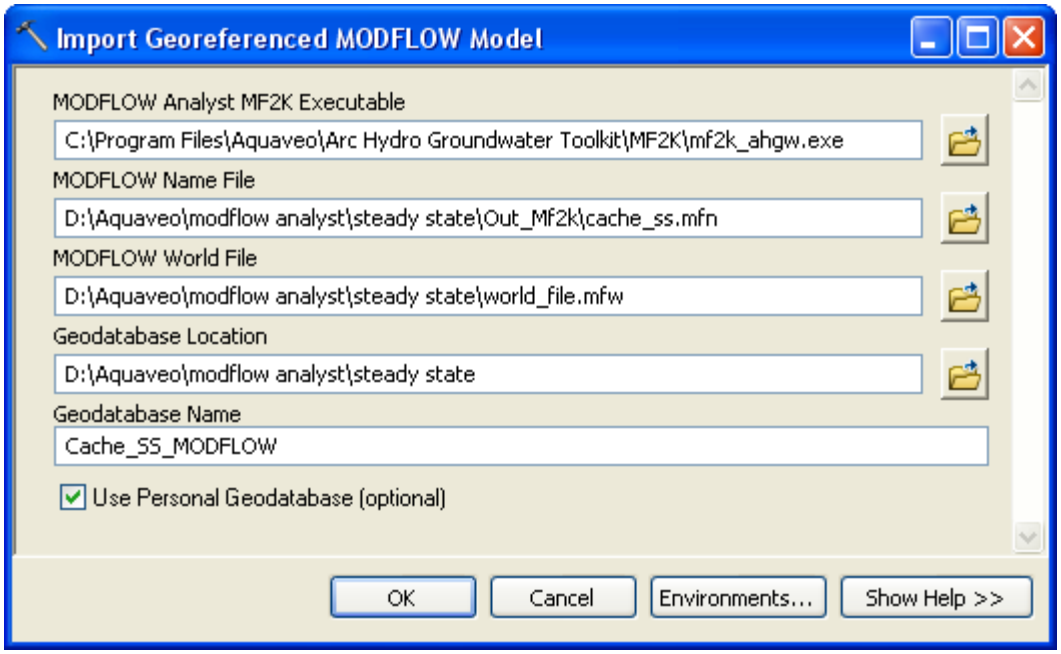


Figure 9 Parameters for the Import Georeferenced MODFLOW Model tool.

After running the tool you should see three new feature layers in the map: *Boundary*, *Cell2D*, and *Node2D*. A set of tables has also been created in the geodatabase. Check to see that the MODFLOW tables have been added to the map by selecting the *Source* tab in the ArcMap *Table of Contents* window. If the tables were not added to the map, add them from the *Cache_SS_MODFLOW.mdb* geodatabase.

To review the data:

13. Right-click on the *Cell2D* layer and select the *Open Attribute Table* command to view the fields associated with the features. Close the window when finished. You may wish to repeat this step for the *Node2D* and *Boundary* features.

14. Click on the *Source* tab at the bottom of the *Table of Contents* window and note the list of MODFLOW tables. Right-click on some of the tables and select the *Open* command to view the contents.

Before continuing to the next step, we will turn off the display of the features.

15. Toggle **off** the *Cell2D*, and *Node2D* features.

6 Building Active Boundary Polygons

We can now use the Cell2D and Node2D features to create map layers illustrating the MODFLOW data. To start with, we will use the *IBOUND to Polygon* tool to create a map layer containing polygons corresponding to the active region for each of the model grid layers. This tool uses the *IBOUND* field in the *Basic* table and the *Cell2D* feature class as input. Active cells have non-zero IBOUND values. To run the tool:

1. Double-click on the ***IBOUND To Polygon* tool** in the *MODFLOW Analyst|Views* toolset.

2. Click on the down arrow on the right side of the *Input Cell2D Features* field and select the **Cell2D** feature class.

3. Click on the down arrow on the right side of the *Input Basic Table* field and select the **Basic** table.

4. Click on the down arrow on the right side of the *IBOUND Array Field* field and select **IBOUND**.

5. Click on the down arrow on the right side of the *Input Index Table* field and select the **CellIndex** table.

6. Click on the *Open* button on the right side of the *Output IBOUND Polygon Feature Class* field and browse to the Layers feature dataset where the MODFLOW feature classes were created (Cache_SS_MODFLOW.mdb\Layers). Enter **ActiveBoundary** for the name of the new feature class and select *Save*.

7. Leave the *Layer ID (optional)* field blank. Entering an integer in this field results in an active boundary polygon for the selected layer. If the field is left blank, an active boundary polygon is created for each layer.

At this point, the settings for the tool should match those shown in Figure 10.

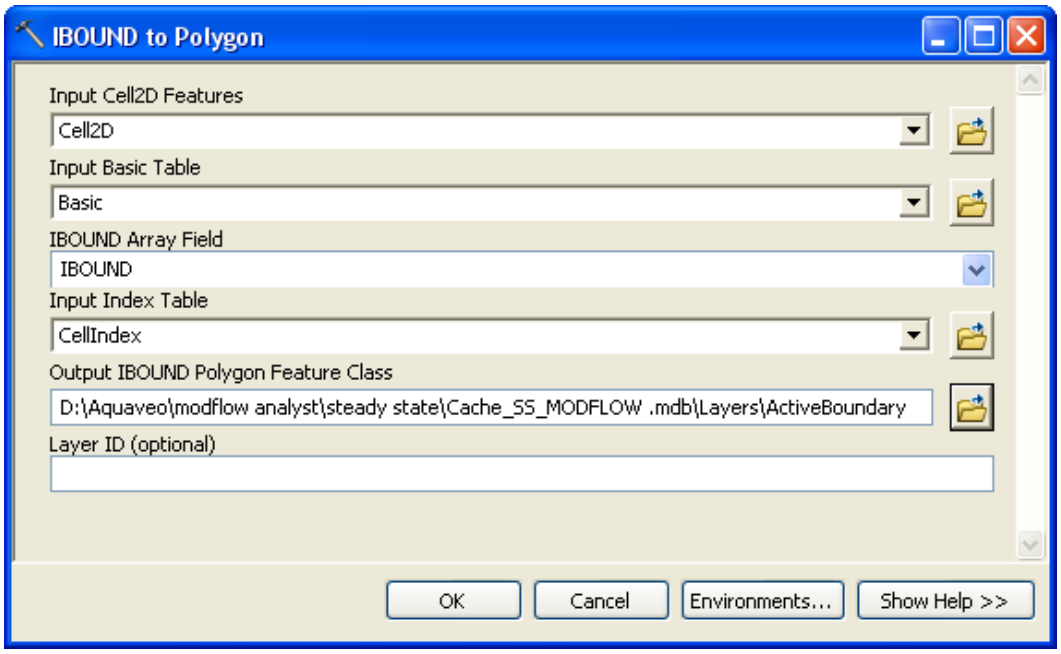


Figure 10 Settings for the IBOUND to Polygon tool.

8. Click *OK* to launch the tool.

9. When the tool is finished, click the *Close* button.

You should see a set of overlapping polygons appear, indicating the active regions for each of the six grid layers.

10. Symbolize the polygons based on the CellIndex_K attribute to better visualize the active zones of different layers.

7 Using the MODFLOW Grid Layer (K) Filter

The *IBOUND to Polygon* tool created a feature class containing overlapping polygons (one for each model layer). One of the fields in the feature class is the "*K"* field indicating the index of the grid layer. To view the polygons one at a time, we could apply a definition query (K=1) to our current map layer using the *Layer Properties* dialog. The *MODFLOW Analyst* toolbar contains a convenient shortcut for creating a definition query based on the grid layer. To use the filter:

1. Make sure the *ActiveBoundary* layer is selected in the *Table of Contents* window.

2. Locate the ***K:*** filter 

in the *MODFLOW Analyst* toolbar and note that the default value is 0. This value results in the display of all layers at once. Click on the up arrow to the right of the 0 to increment the value to 1.

3. Repeat the previous step to view the active boundary polygon for other layers.

The *K:* filter will work for any map layer containing a K field. To apply it to multiple map layers at once, simply multi-select the map layers in the *Table of Contents* window prior to changing the value in the K: filter.

8 Using the Make MODFLOW Feature Layer tool

Next, we will create a map layer of hydraulic conductivity values found in the BCF package. We will use the *Make MODFLOW Feature Layer* tool.

The hydraulic conductivity values we will be mapping are stored in the BCFProperties table. This table also contains other values including transmissivity (Tran), and leakance (VCont). These values are stored in the BCF Package files as a series of 2D arrays, one per layer per type. Each record in the table represents a set of values associated with a particular cell, identified by an IJK value.

1. Double-click on the ***Make MODFLOW Feature Layer*** **tool** in the *MODFLOW Analyst|Views* toolset.

2. For the *Input Cell/Node Features* select **Cell2D**.

3. For the *Input MODFLOW Table* select **BCFProperties**.

4. Select the **HY and IJK fields** in the *MODFLOW Table Fields of Interest*.

5. Name the *Output MODFLOW Layer* **HY**.

The settings in the tool should now match those shown in Figure 11.

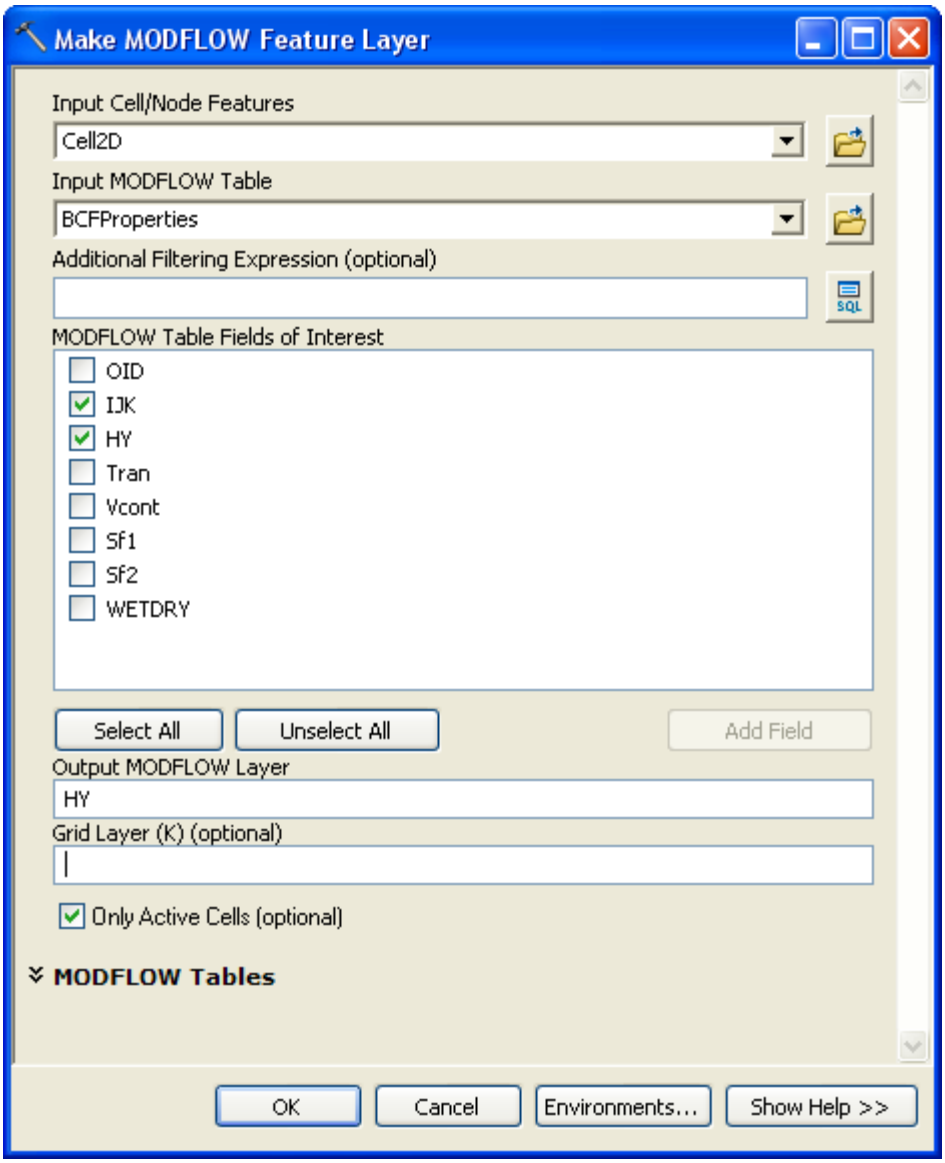


Figure 11 Settings for the Make MODFLOW Feature Layer tool.

6. Click on the *OK* button.

7. When the tool is finished, click on the *Close* button.

The HY layer created is a temporary layer in ArcMap.

At this point you should see a new map layer appear in the *Table of Contents* window and you should see a new set of cell polygons appear in the display. Next, we will modify the display of the new *HY* map layer.

8. Right-click on the *HY* map layer and select the *Properties* command.

9. Click on the *Symbology* tab.

This model uses interpolated hydraulic conductivity, so we will use graduated colors rather than categories.

10. In the *Show:* section, click on the *Quantities* item and select the *Graduated Colors* option.

11. In the *Value* field, select the *BCFProperties_HY* item.

12. Click on the *Classify* button.

13. Change the *Classes* value to **10**.

14. Click on the *OK* button to exit the *Classification* dialog.

At this point, your selections in the *Symbology* tab of the *Layer Properties* dialog should match those shown in Figure 12.

15. Click on the *OK* button to exit the *Properties* dialog.

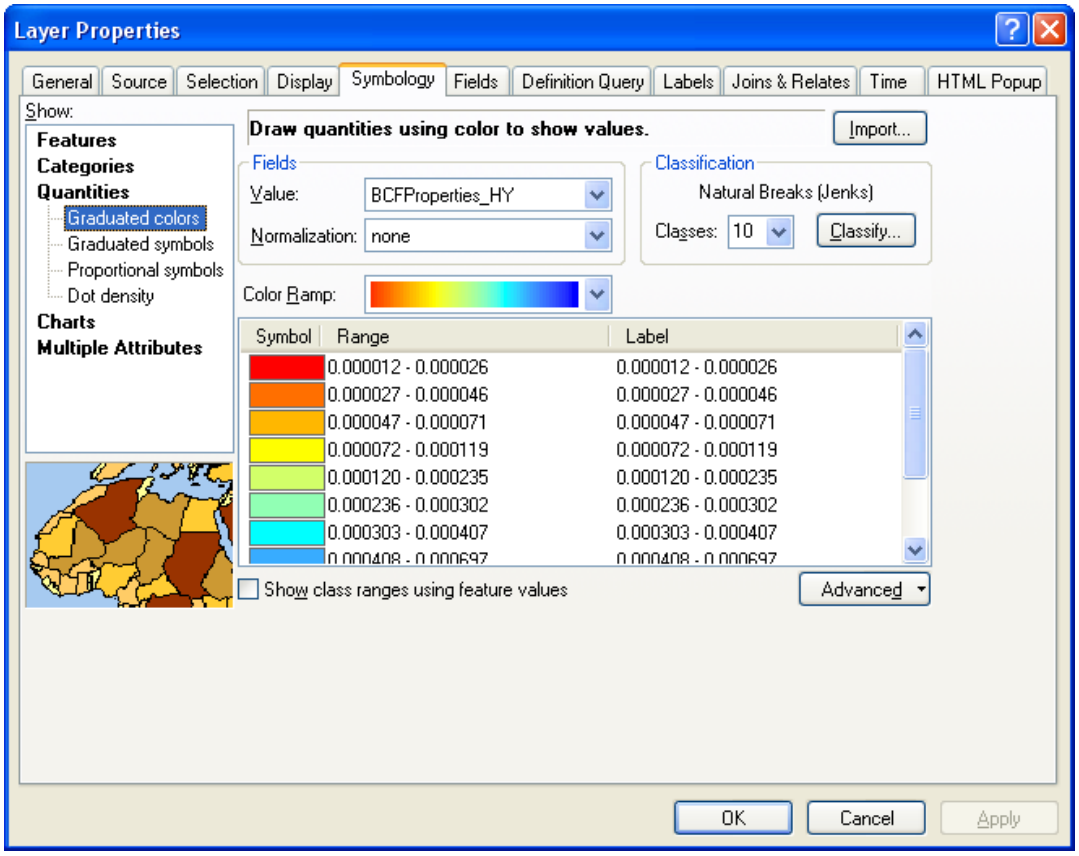


Figure 12 Settings for the Layer Properties dialog.

The HY map layer illustrates the hydraulic conductivity for all active MODFLOW cells in layer 1 of the model (other layers in the model have transmissivity values assigned to the cells).

9 Using the Create MODFLOW Features Tool

Now we will repeat the process of building a map layer but this time we will use the *Create MODFLOW Features* tool. This tool is part of *MODFLOW Analyst* and is built on top of the *Make Query Table* tool. It simplifies the process of building a map layer by automating the construction of the SQL query. We will make a map layer illustrating the leakance (VCont) values from the BCFProperties table.

1. Double-click on the *Create MODFLOW Features* tool in the *MODFLOW Analyst|Views* toolset.

2. This tool makes map layers out of Cell2D, Node2D, and Node3D features. The *Input Cell/Node Features* field is used to specify which type of feature is to be used in the query. Click on the down arrow for this field and select the **Cell2D** feature class.

3. For the *Input MODFLOW Table* field, click on the down arrow and select the **BCFProperties** table.

4. The *Additional Filtering Expression* field can be used to specify any additional items to the SQL query that are not part of the standard query. In this case we will **leave it empty**.

5. The *MODFLOW Table Fields of Interest* controls are used to select which of the fields from the MODFLOW table will be added to the new feature layer. In this case, we are only interested in the **VCont** field.

6. The *Output MODFLOW Feature Class* field is used to specify the name and location of the new feature class that will be created by the tool. Click on the *Open* button to the right of the field and browse to location in the geodatabase where the MODFLOW features are stored (*Cache_SS_MODFLOW.mdb\Layers*). Enter **VCont** for the name and click *Save*.

7. With the *Grid Layer (K)* filter you can select to map only a specific layer. Leave the *Grid Layer (K)* value **empty** to map all layers.

8. The *Only Active Cells toggle* is optional. If it is left checked, only active cells will be used in the query.

9. The *MODLOW Tables* category includes parameters specifying the *Basic, BasicArrayMult, DISVars,* and *CellIndex* tables. Expand the tab and make sure the Basic and CellIndex tables are specified correctly.

The settings in the tool should now match those shown in Figure 13.

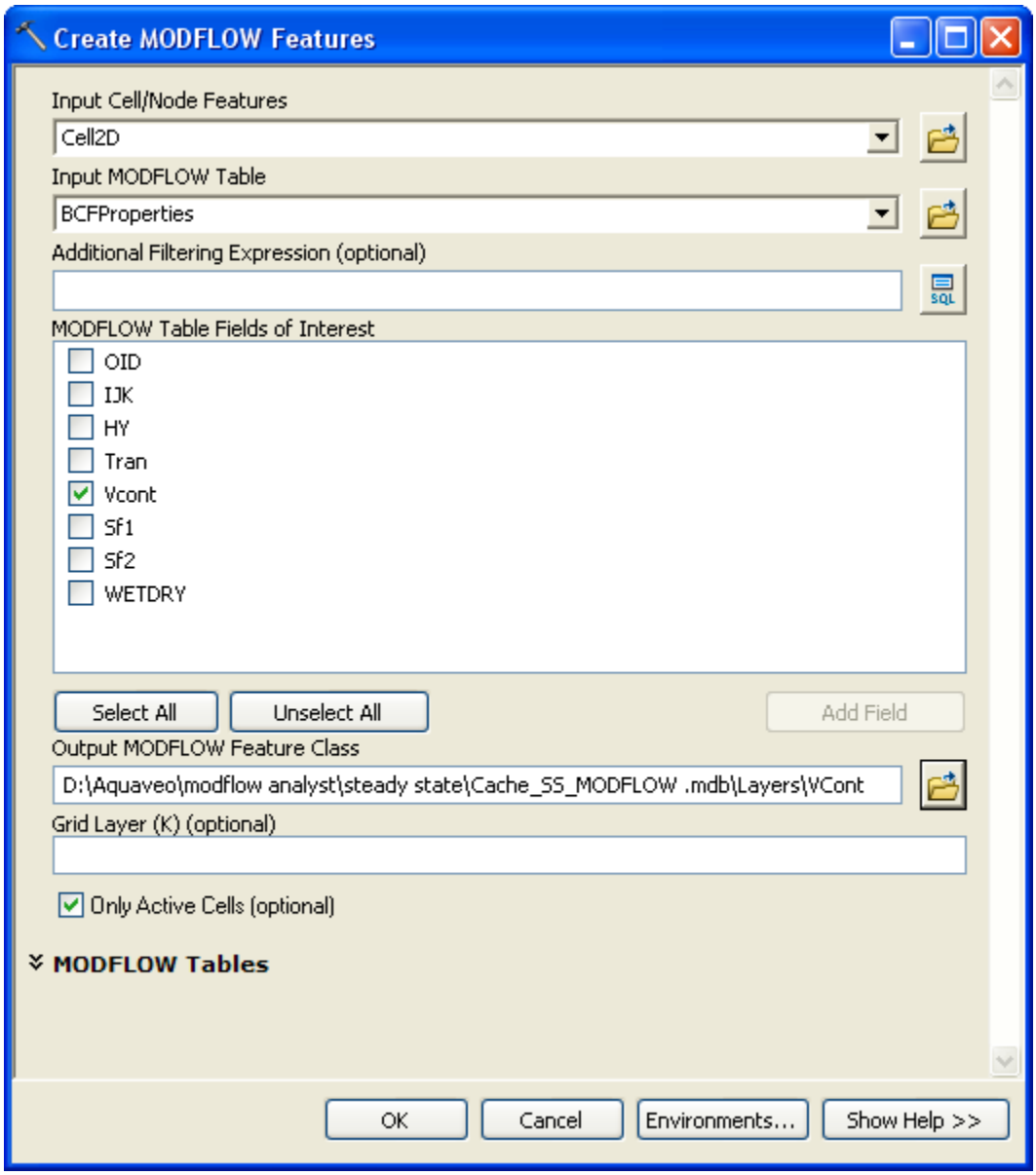


Figure 13 Settings for the Create MODFLOW Features tool.

10. Click on the *OK* button.

11. When the tool is finished, click on the *Close* button.

12. You should see a new *VCont* layer appear in the *Table of Contents*. Once again, you may wish to use the *Layer Properties* dialog to modify the symbology so that the *VCont* values are displayed and use the *K:* filter in the *MODFLOW Analyst* toolbar to isolate and cycle through the grid layers (you may notice that since the VCont values do not apply to the bottom-most layer, layer 6 has no VCont values)

You may wish to repeat these steps to build map layers of the following MODFLOW tables/data using the Cell2D features:

Recharge rates (RCHArrays.RECH)
Evapotranspiration rates (EVTArrays.EVTR)
Bottom elevations (BotmElev.BotmElev)
Starting heads (Basic.STRT)

10 Mapping Drain Package Data

Next, we will use the *Create MODFLOW Features* tool to generate a map layer illustrating the locations of the cell-by-cell drain instances used in the Drain package. We will use the *Node2D* feature class to display the drain cells.

1. Double-click on the *Create MODFLOW Features* tool in the *MODFLOW Analyst|Views* toolset.

2. Click on the down arrow for the *Input Cell/Node Features* field and select the **Node2D** feature class.

3. For the *Input MODFLOW Table* field, click on the down arrow and select the **DRN** table.

4. In the *MODFLOW Table Fields of Interest* section, toggle on the following fields:

   Elevation
   Cond

5. Click on the *Open* button to the right of the *Output MODFLOW Feature Class* field and browse to location where the MODFLOW features are stored (*Cache_SS_MODFLOW.mdb\Layers*). Enter **Drains** for the name and click *Save.*

6. Leave the *Only Active Cells* toggle selected.

7. The *MODLOW Tables* tab includes parameters specifying the *Basic, BasicArrayMult, DISVars,* and *CellIndex* table. Expand the tab and make sure the *Basic* and *CellIndex* tales are specified correctly.

The settings in the tool should now match those shown in Figure 14.

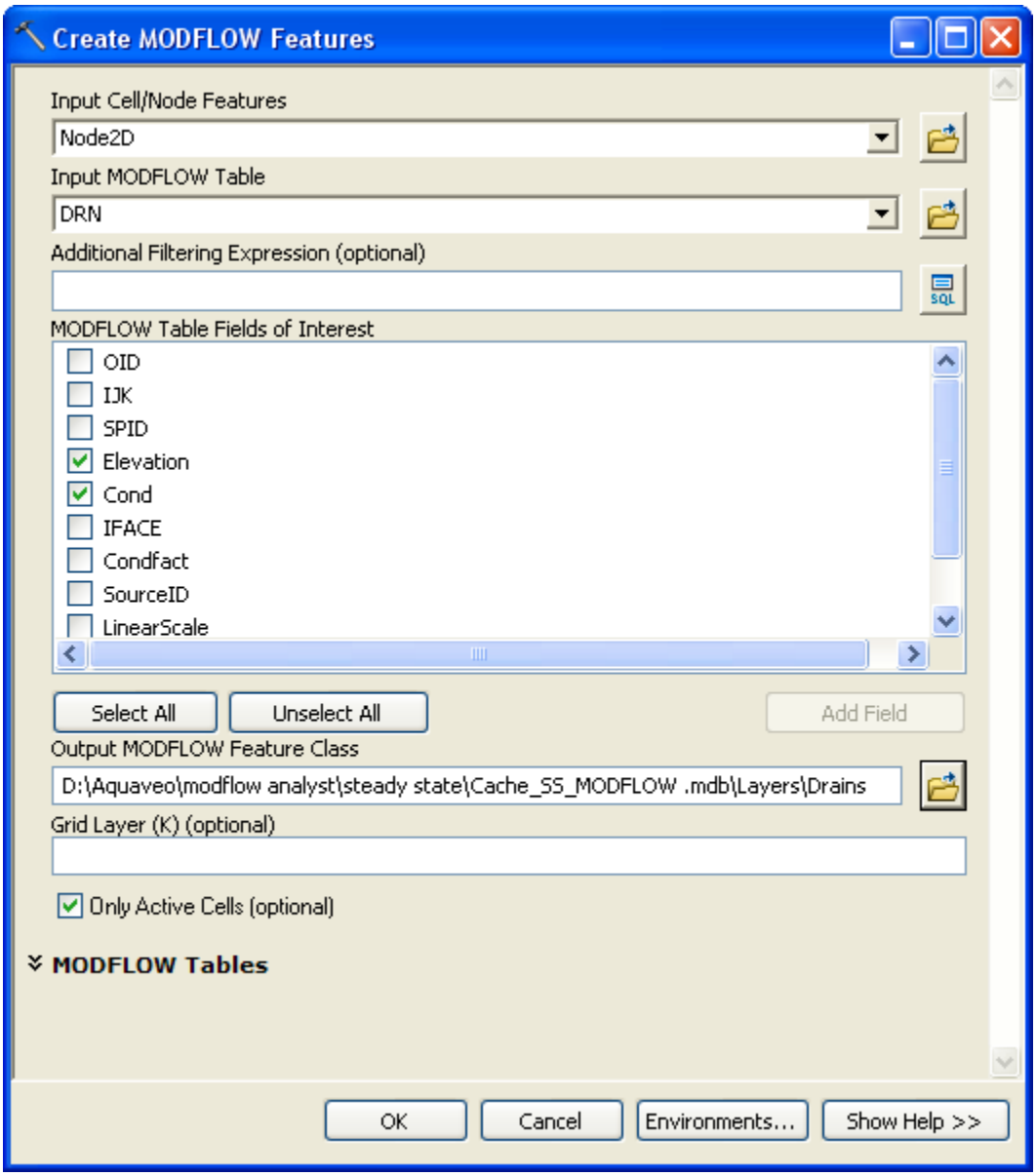


Figure 14 Settings for the Create MODFLOW Features tool.

8. Click on the *OK* button.

9. When the tool is finished, click on the *Close* button.

You should see a new map layer appear called *Drains*. You may wish to use the *Layer Properties* dialog to adjust the symbology. Since the drains are all in layer 1 of the MODFLOW grid, we don't need to use the *K:* filter.

You may wish to repeat these steps to build map layers of the following MODFLOW tables/data using the Node2D features:

Rivers (RIV)
General Head Boundary (GHB)

11 Importing and Displaying Output Data

The output from a MODFLOW simulation includes head, drawdown, and flow data. The MODFLOW Data Model includes a set of tables for storing this data. To view output from a MODFLOW simulation, the first step is to import the output files into the tables. We can then use the *Create MODFLOW Features* tool to display the output data. To import the files:

1. Double-click on the *Import MODFLOW Output* tool in the *MODFLOW Analyst*|*Import* toolset.

2. If necessary, select the appropriate tables for each of the inputs as shown in Figure 15. Notice that you can import separately (or together) Heads, Drawdown, and Flow results. In this example we will import heads.

3. Click the *OK* button.

4. When the tool is finished, click on the *Close* button.

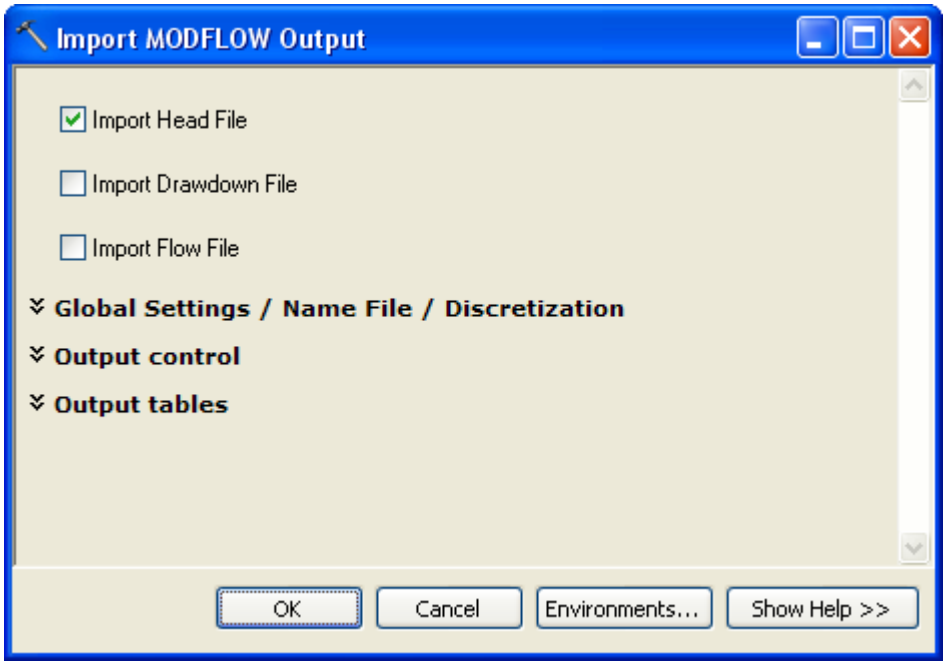


Figure 15 Settings for the Import MODFLOW Output tool.

When the tool is finished, the display will not change because the tool simply imports the output data into the appropriate tables. You can view the data imported by opening the OutputHead table (notice that Heads of 1 represent no value). We will now generate a map layer of heads.

5. Double-click on the ***Create MODFLOW Features*** tool in the *MODFLOW Analyst*|*Views* toolset.

6. Click on the down arrow for the *Input Cell/Node Features* field and select the **Cell2D** feature class.

7. For the *Input MODFLOW Table* field, click on the down arrow and select the **OutputHead** table.

8. In the *MODFLOW Table Fields of Interest* section, toggle on the **Head** field:

9. Click on the *Open* button to the right of the *Output MODFLOW Feature Class* box and browse to location in the geodatabase where the MODFLOW features are stored (*Cache_SS_MODFLOW.mdb\Layers*). Enter **Heads** for the name and click *Save*.

The settings in the tool should now match those shown in Figure 16.

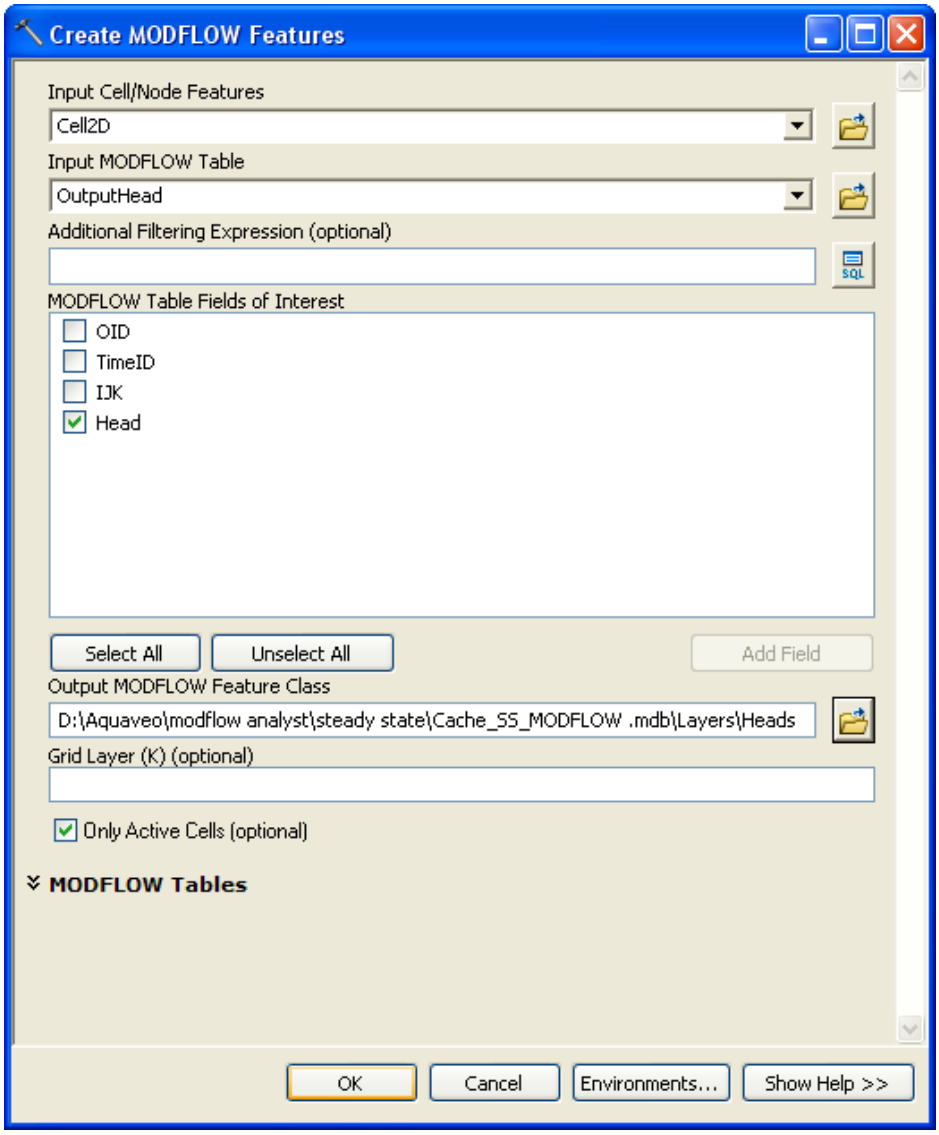


Figure 16 Settings for the Create MODFLOW Features tool.

10. Click on the *OK* button.

11. When the tool is finished, click on the *Close* button.

Next, we will set up the layer symbology:

12. Right-click on the *Heads* layer and select the *Properties* command.

13. Click on the *Symbology* tab.

14. In the *Show:* section, click on the *Quantities* item and select the *Graduated Colors* option.

15. In the *Value* field, select the *OutputHead_Head* item.

16. Click on the *Classify* button.

17. Change the *Classes* value to **30**.

18. Click on the *OK* button to exit the *Classification* dialog.

At this point, your selections in the *Symbology* tab of the *Properties* dialog should match those shown in Figure 17.

19. Click on the *OK* button to exit the *Properties* dialog.

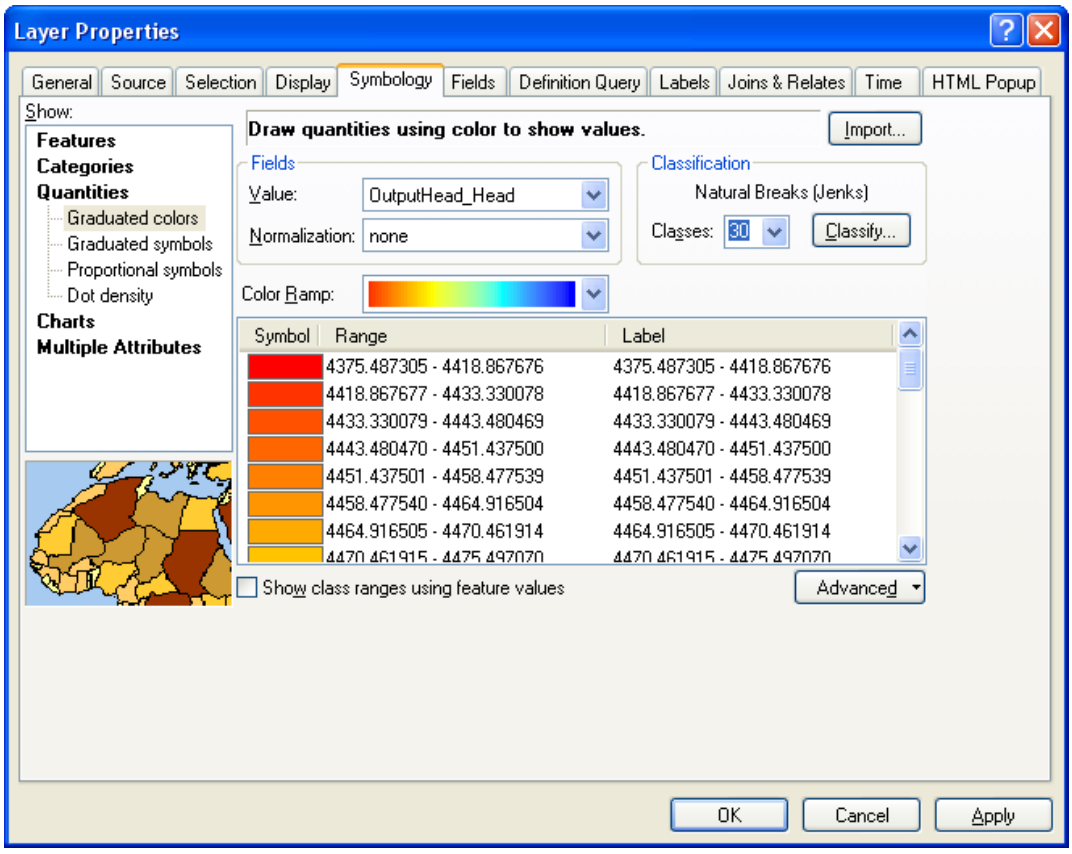


Figure 17 Settings for the Layer Properties Dialog.

The cells corresponding to the *Heads* layer should now be colored. To view the heads layer by layer, make sure the *Heads* layer is selected and use the **K:** filter in the *MODFLOW Analyst* toolbar.

12 Creating Cell3D Features

Thus far in the tutorial we have been working with 2D features in ArcMap. For some models it is useful to generate 3D representations of the MODFLOW data that can be visualized in ArcScene. This can be accomplished using the Cell3D and Node3D features. As a final step in the tutorial, we will create a set of Cell3D features and view them in ArcScene. To complete this step, you must have a *3D Analyst* license.

Cell3D features are built from the Boundary polygon and discretization tables containing the top and bottom elevation arrays. The cells are constructed for active cells only using the IBOUND values in the Basic table.

We will first need to create the Cell3D feature class using the Catalog Window.

1. Launch the Catalog Window  .
2. Navigate to the feature dataset containing the MODFLOW features (*Cache_SS_MODFLOW.mdb\Layers*). Right-click on the **Layers** feature dataset and select *New|Feature Class* command.
3. Enter **Cell3D** for the *Name* field.
4. Select ***MultiPatch Features*** for the *Type of features*.
5. Select the *Next* button.
6. Select *Finish* button.

A new Cell3D feature class is created in the Layers feature dataset.

7. Add the Cell3D feature class to the map and close the Catalog Window.

To create the Cell3D features:

8. Double-click on the *Create MODFLOW Cell3D* tool in the *MODFLOW Analyst|Features* toolset.
9. If not already selected, click on the down arrow to the right of the *Input Boundary Polygon Feature* field and select the **Boundary** feature class.

10. If not already selected, click on the down arrow to the right of the *Input Cell3D Features* field and select the **Cell3D** feature class created in the previous step.

11. Make sure the *Basic Package Tables and Discretization Tables* are all populated.

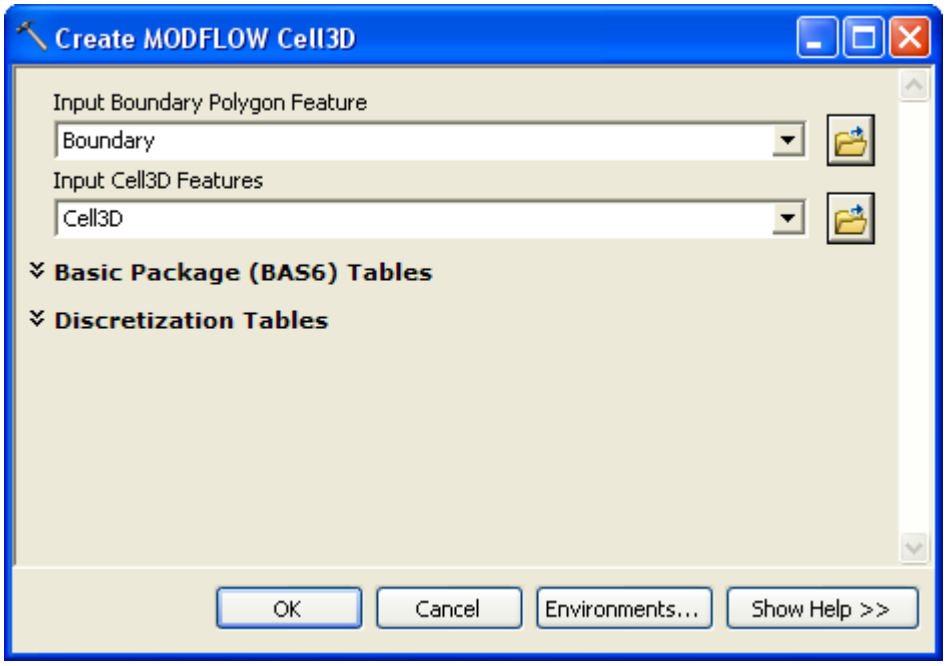


Figure 18 Settings for the Create MODFLOW Cell3D tool.

12. Click on the *OK* button.

13. When the tool has finished running (this can take a few minutes), click on the *Close* button.

To view the 3D cells we will use ArcScene:

14. Open ArcScene.

15. Add the Cell3D features to the scene using the *Add Data* command .

You should see a new set of Cell3D features added to the Scene.

16. Save the scene.

To better visualize the cells we will adjust the Scene's properties:

17. Select *View|Scene Prooperties* and change the Vertical Exaggeration option to 20.

18. Select *OK* to exit the Scene Properties settings.

You can symbolize the features by model layer (K) as shown in Figure 19:

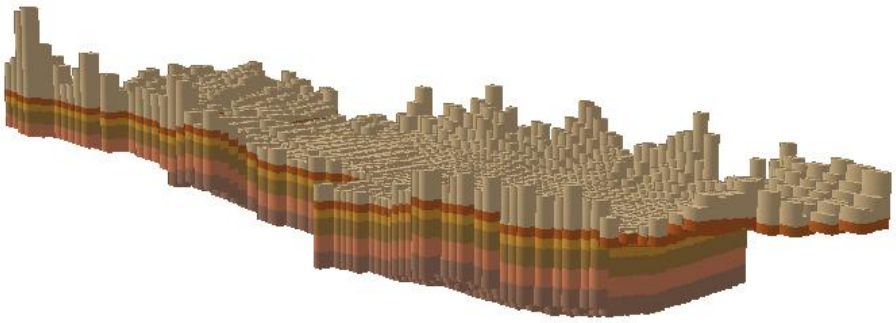


Figure 19 3D view of MODFLOW cells in ArcScene.

13 Conclusion

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

- The MODFLOW Data Model consists of a set of polygon, point, and multipatch features and a set of tables containing MODFLOW data. The Data Model represents a complete MODFLOW model.
- A MODFLOW model can be imported into ArcGIS in one step using the *Import Georeferenced MODFLOW Model* tool.
- The *Make Query Table* and the *Create MODFLOW Features* tools can be used to generate map layers using Cell2D and Node2D features.
- For map layers that include features from multiple grid layers, the *K:* filter can be used to quickly set up a definition query for a selected grid layer.
- MODFLOW solutions can be imported using the *Import MODFLOW Output* tool.
- Cell3D features can be used to display MODFLOW models in ArcScene.

