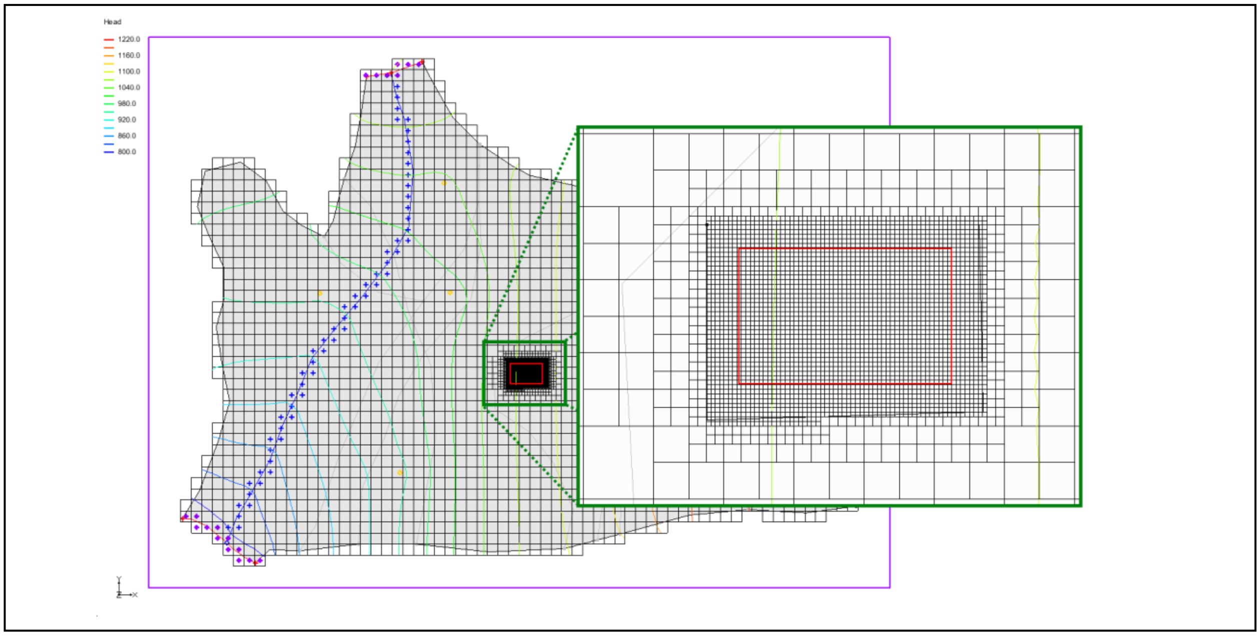
v. 10.1

GMS 10.1 Tutorial

MODFLOW-USG – Regional to Local Model Conversion

Create a locally refined area in a regional model using MODFLOW-USG and GMS



Objectives

Use the tools provided in GMS to locally refine an area in a regional model.

Prerequisite Tutorials

- MODFLOW – Conceptual Model Approach I
- MODFLOW-USG – Quadtree
- UGrid Creation

Required Components

- Grid Module
- Geostatistics
- Map Module
- MODFLOW

Time

- 15–30 minutes

1 Introduction

MODFLOW–USG (or UnStructured Grid), was developed to support a wide variety of structured and unstructured grid types, including nested grids and grids based on prismatic triangles, rectangles, hexagons, and other cell shapes. Flexibility in grid design can be used to focus resolution along rivers and around wells, for example, or to subdiscretize individual layers to better represent hydrostratigraphic units.[1]

In Figure 1—taken from the MODFLOW-USG documentation[2]—notice the grid labeled "H". This is an example of a nested grid. This is the desired outcome with a Regional to Local Model conversion. MODFLOW-LGR allows for multiple nested grids and runs two or more coupled MODFLOW simulations. With MODFLOW-USG, simply refine the grid around the area of interest to end up with only one MODFLOW simulation to run.

In this tutorial, a regional MODFLOW 2000 model will be imported and a MODFLOW-USG model with local refinement will be created. A MODFLOW-USG simulation will be created, and the layer data will be converted to a scatter point dataset. The layer data will be interpolated and mapped from the conceptual model to MODFLOW. MODFLOW will then be run.

This tutorial assumes familiarity with conceptual modeling, MODFLOW-USG, and unstructured grid generation. The tutorials listed as prerequisites on the cover page of this document should be completed prior to starting this tutorial.

[1] Panday, Sorab; Langevin, Christian.D.; Niswonger, Richard G.; Ibaraki, Motomu; and Hughes, Joseph D., (2013). "MODFLOW–USG version 1: An Unstructured Grid Version of MODFLOW for Simulating Groundwater Flow and Tightly Coupled Processes Using a Control Volume Finite-Difference Formulation" in *Techniques and Methods 6–A45*,U.S. Geological Survey, 66 p.

[2] Ibid, p. 9.

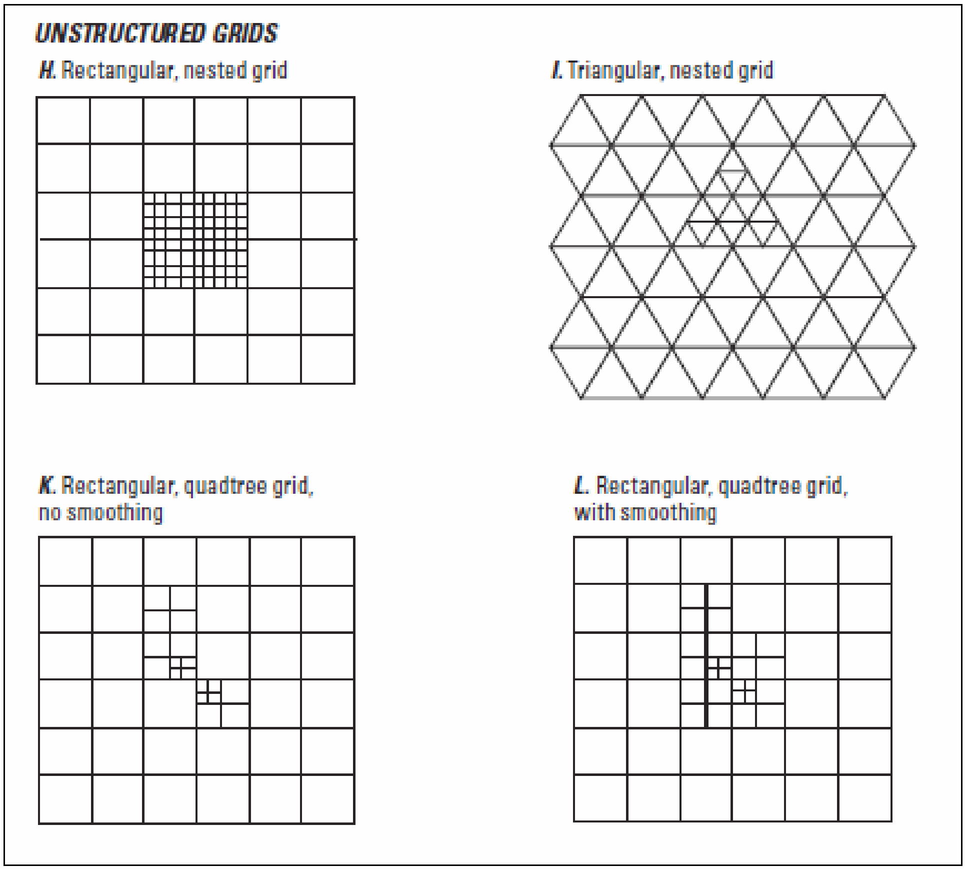


Figure 1 Examples of unstructured grids from the MODFLOW-USG documentation

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.

2.1 Reading in the Regional Model

The first step in the model conversion process is to build a regional model. Since the focus of this tutorial is primarily on the conversion process, import a previously constructed model.

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-USG\Reg2Loc* directory and select "regmod.gpr".

4. Click **Open** to import the project and exit the *Open* dialog.

A model similar to Figure 2 should appear.

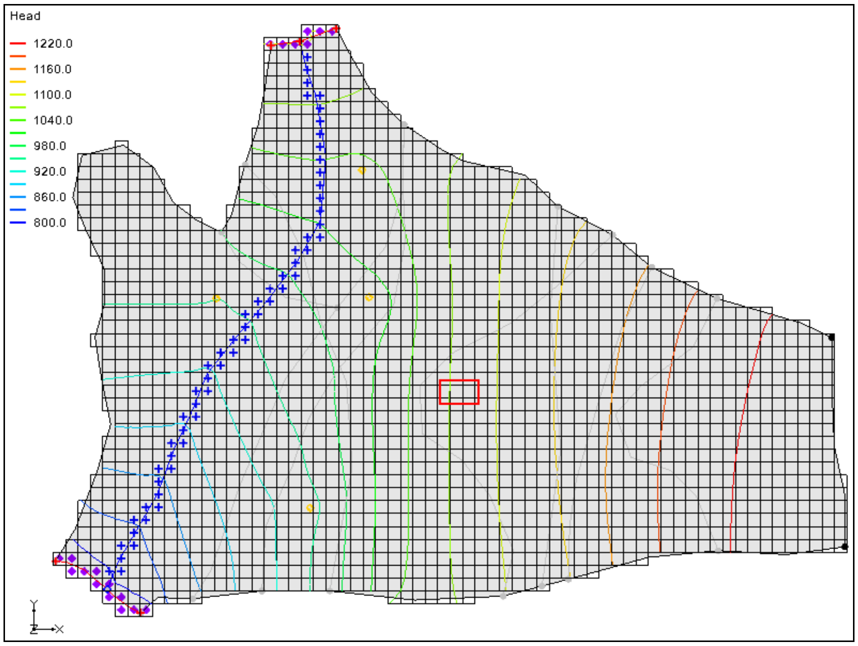


Figure 2 Regional MODFLOW 2000 model

This is the top layer of the two layer model. This model was constructed using the conceptual model approach. The boundary of the local site is indicated with a red rectangle. The imported project includes the solution for the regional MODFLOW 2000 model.

2.2 Saving with a Different Name

Before making any changes, save the project under 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. Enter "refined.gpr" as the *File name*.
4. Click **Save** to save the project under the new name and close the *Save As* dialog.

Periodically **Save** as the model is developed.

3 Creating a UGrid

Now create a 3D UGrid. This grid needs to match the MODFLOW 2000 (mf2k) grid except that the grid will be refined around the local site using a grid frame with the same origin and extents as the mf2k grid. A map polygon will be used to define the refined area around the local site.

1. Right-click in a blank space in the Project Explorer and select *New* | **Grid Frame**.
2. Right-click on " Grid Frame" in the Project Explorer and select **Fit to Active Coverage**.
3. Fully expand " 3D Grid Data", then right-click on " grid" and select **Properties…** to open the *Properties* dialog.
4. Select the cell in the *Value* column of the *X origin* row and, while holding down the *Shift* key, select the cell in the *Value* column of the *Length in Z* row.

This selects a total of six cells (Figure 3).

5. Right-click on one of the selected cells and select **Copy**.

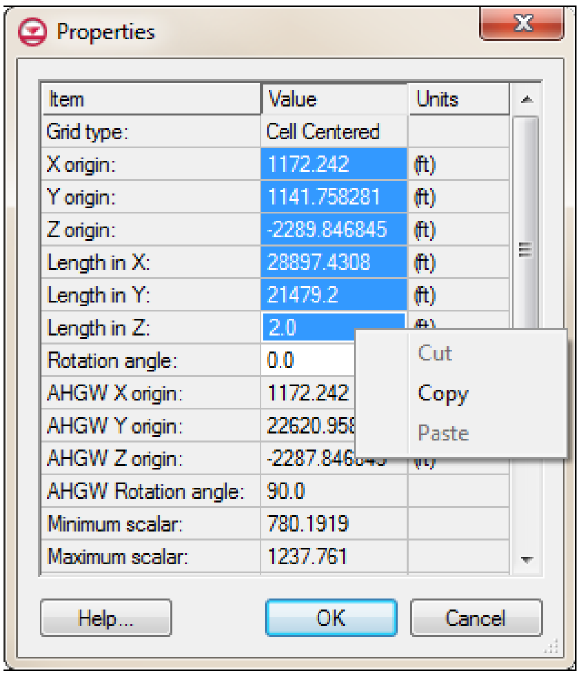


Figure 3 3D Grid Properties dialog

6. Click **Cancel** to exit the dialog.
7. Right-click on " Grid Frame" and select **Properties…** to open the *Grid Frame Properties* dialog.
8. Select the cell in the *Value* column of the *Origin X* row and, while holding down the *Shift* key, select the cell in the *Value* column of the *Dimension z* row.
9. Right-click on one of the selected cells and select **Paste**.

The values will change to what was copied from the 3D grid properties.

10. Click **OK** to exit the *Grid Frame Properties* dialog.
11. **Frame** the project.

This displays the entire model area with the grid frame (Figure 4).

Figure 4 Framed view with copied properties

3.1 Defining the Refined Area

It is now possible to define the refined area around the local site by editing the "ss" coverage.

1. Fully expand the " Regional Model" in the Project Explorer and double-click on the " ss" coverage to bring up the *Coverage Setup* dialog.
2. Turn on *Refinement* in the *Sources/Sinks/BCs* column.
3. Click **OK** to exit the *Coverage Setup* dialog.
4. Turn off " grid" in the Project Explorer to hide the 3D grid.
5. Using the **Create Arc** tool, click out an arc surrounding the local site (the red rectangle). Close the arc by double-clicking on the start point.
6. Click **Build Polygons** to make the newly digitized arc into a polygon (see the black arc surrounding the red rectangle in Figure 5).

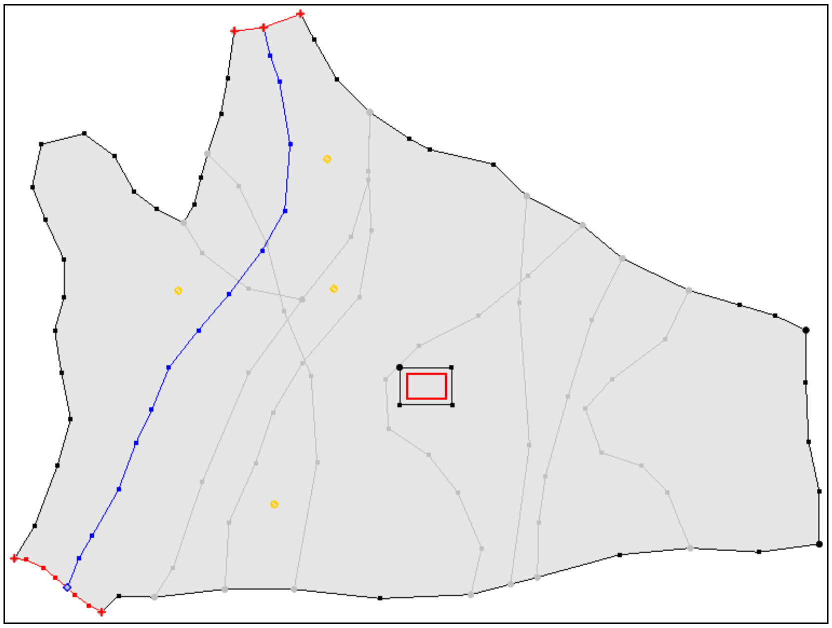


Figure 5 New polygon digitized around the local site

7. Using the **Select Polygon** tool, double-click on the new polygon to bring up the *Attribute Table* dialog.
8. Click the box in the *Refine* column.
9. Enter "50.0" in the *Base size (ft)* column.
10. Click **OK** to exit the *Attribute Table* dialog.

3.2 Creating a 3D Refined UGrid

Now create the 3D refined UGrid.

1. Right-click on " Grid Frame" and select *Map to* **| UGrid** to bring up the *Map → UGrid* dialog.
2. Select "3D" from the *Dimension* drop-down.
3. Select "Quadtree/Octree" from the *UGrid type* drop-down.
4. In the *X-Dimension* section, enter "70" for the *Number of cells*.
5. In the *Y-Dimension* section, enter "50" for the *Number of cells*.
6. In the *Z-Dimension* section, enter "2" for the *Number of cells*.
7. Click **OK** to exit the *Map → UGrid* dialog and create the UGrid.

A UGrid similar to Figure 6 should appear in the Graphics Window.

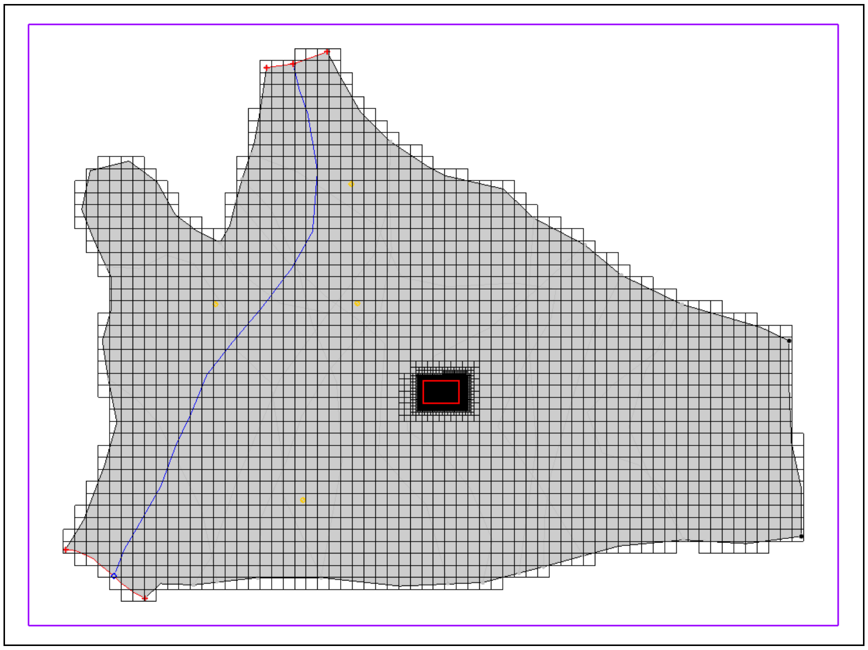


Figure 6 Locally refined UGrid

The larger cells in the UGrid exactly match the mf2k grid. The cells gradually become smaller around the area of interest. Zoom in on the local site to see something similar to Figure 7.

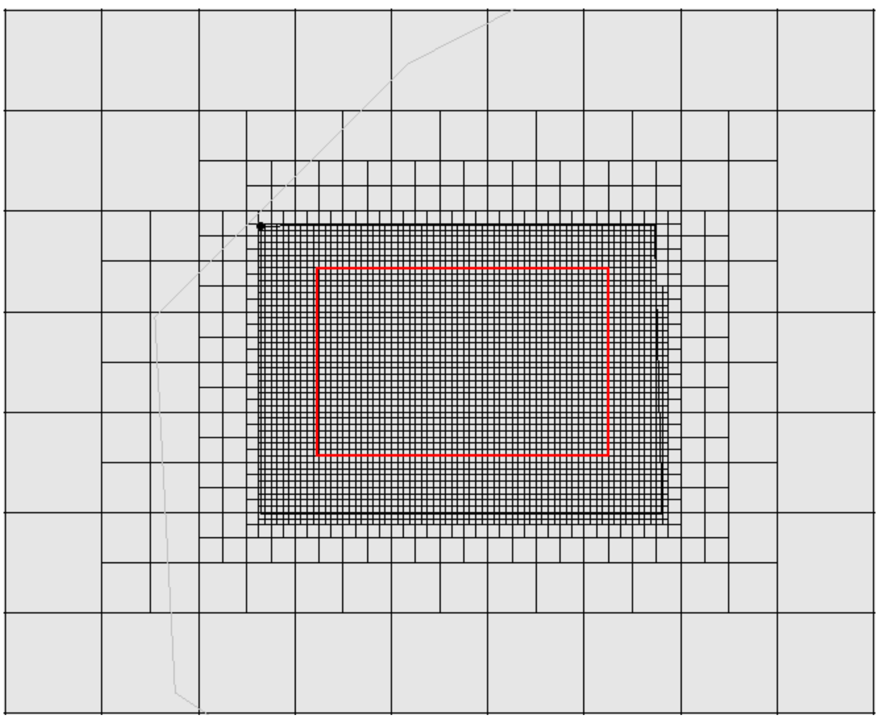


Figure 7 Local refinement of a 3D UGrid

8. **Frame**  the project to view the entire model area.

4 Converting the Layer Data to a Scatter Point Set

Now convert the MODFLOW 2000 layer elevation information to a scatter point set so that it is possible to interpolate the elevations to the UGrid. By default, this will create a new scatter set with the MODFLOW top and bottom elevations as datasets.

1. Select the " 3D Grid Data" folder in the Project Explorer to make it active.
2. Select *Grid* | **MODFLOW Layers → 2D Scatter Points…** to open the *MODFLOW Layers → Scatter Points* dialog.
3. Click **OK** to exit the *MODFLOW Layers → 2D Scatter Points* dialog and create the layer elevation scatter points (Figure 8).

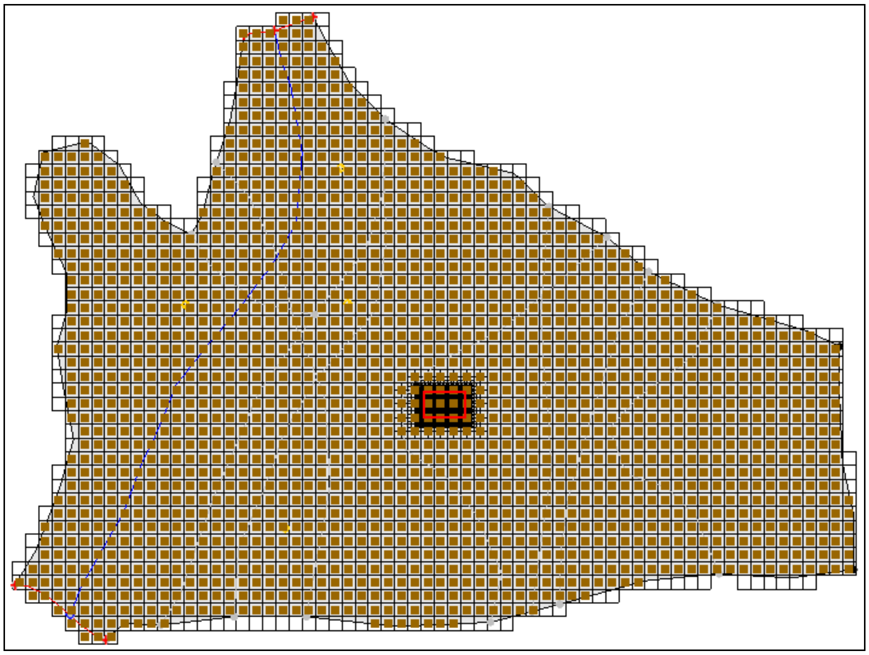


Figure 8 2D scatter points converted from MODFLOW layers

5 Creating a MODFLOW-USG Model

Now it is necessary to create a MODFLOW-USG model on the UGrid before interpolating the elevations.

1. Right-click on " ugrid" in the Project Explorer and select **New MODFLOW…** to bring up the *MODFLOW Global/Basic Package* dialog.
2. Click **OK** to accept the default model settings and exit the *MODFLOW Global/Basic Package* dialog.

6 Interpolating Layer Elevations

Next, interpolate the layer elevations directly to the MODFLOW arrays. The MODFLOW arrays can be automatically associated with appropriately named datasets. Just accept the defaults in the dialog and the layer elevations will be interpolated to the correct MODFLOW array.

1. Right-click on " Layers" in the Project Explorer and select *Interpolate To* | **MODFLOW Layers…** to bring up the *Interpolate to MODFLOW Layers* dialog.
2. Click **OK** to accept the defaults and exit the *Interpolate to MODFLOW Layers* dialog.
3. Turn off the " Layers" scatter set in the Project Explorer to hide it.

The Graphics Window should appear similar to Figure 9.

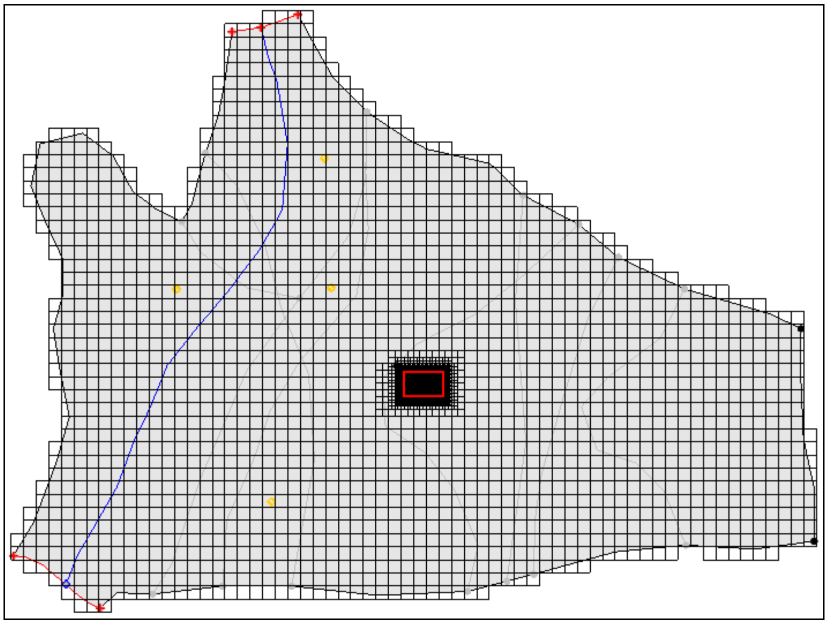


Figure 9 After the scatter set has been interpolated

7 Mapping to MODFLOW

Now assign the MODFLOW boundary conditions and the aquifer properties.

1. Right-click on " Regional Model" in the Project Explorer and select *Map To* | **MODFLOW/MODPATH** to bring up the *Map → Model* dialog.
2. Click **OK** to accept the defaults and close the *Map → Model* dialog.

Boundary condition symbols for specified head, rivers, and wells should appear similar to Figure 10.

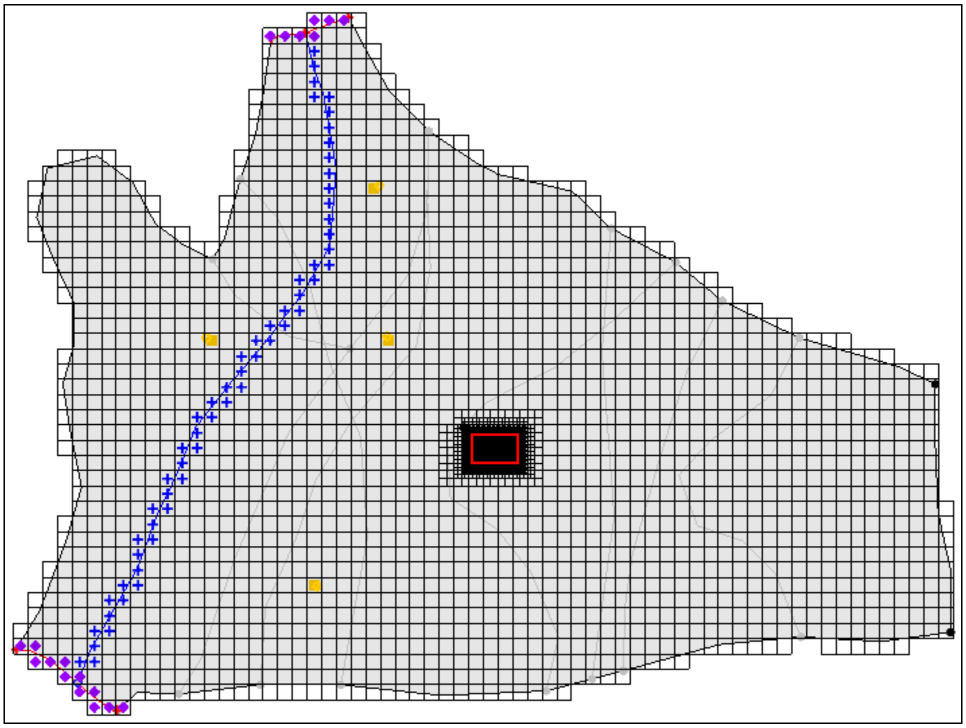


Figure 10 Boundary condition symbols are now visible

8 Saving and Running MODFLOW

Now it is possible to run MODFLOW.

1. **Save** the project.
2. **Run MODFLOW** to bring up the *MODFLOW* model wrapper dialog.
3. When the model 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* dialog.

The contours should be similar to Figure 11.

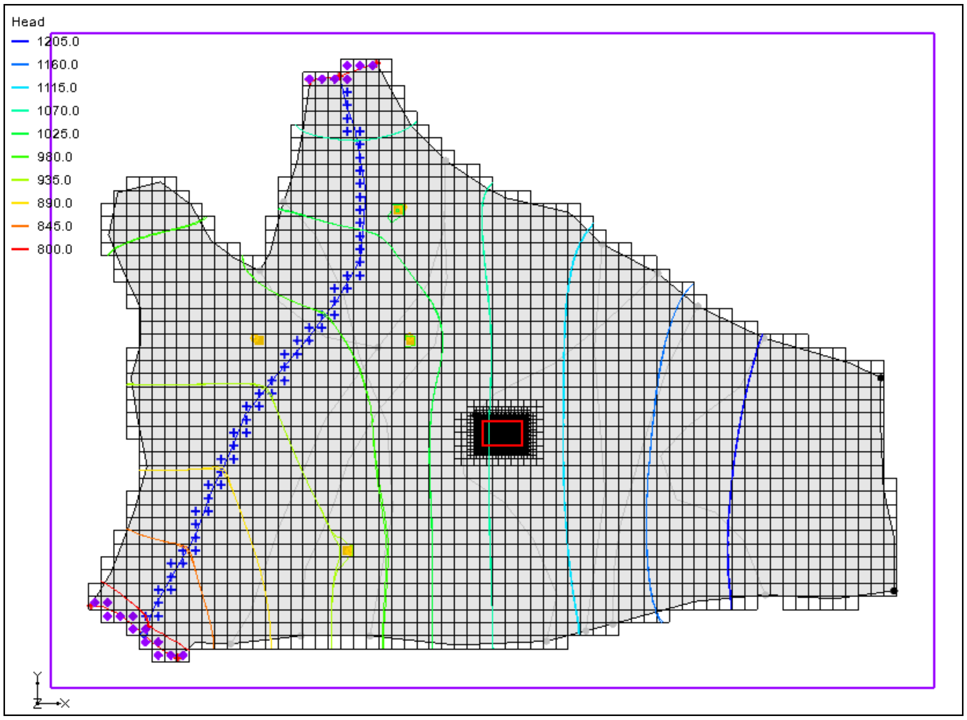


Figure 11 MODFLOW-USG Head Contours

9 Conclusion

This concludes the *Transient Regional to Local Model Conversion* tutorial. The following key concepts were discussed and demonstrated in this tutorial:

- MODFLOW-USG supports locally refined grids.
- Creating locally refined UGrids in GMS.

