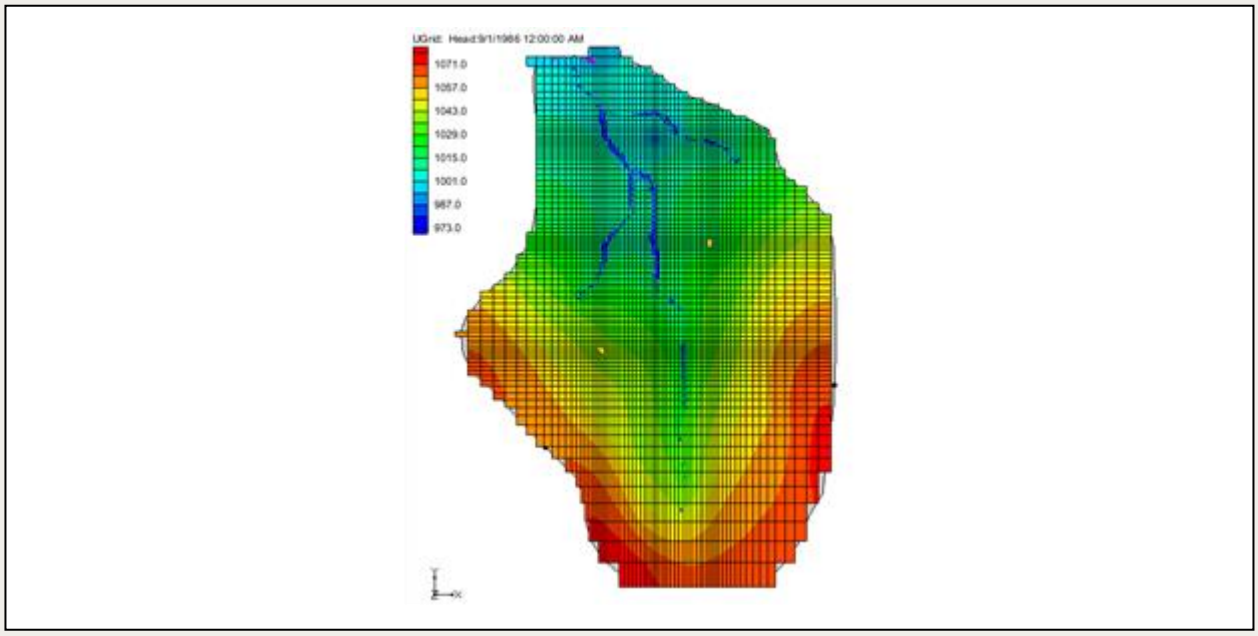
GMS 10.8 Tutorial

MODFLOW 6 – Building a Transient Model

Creating transient MODFLOW 6 models with time-varying inputs



Objectives

GMS provides a powerful suite of tools for inputting and managing transient data. These tools allow all data to be managed using a date/time format that eliminates much of the extra data processing that is often required with modeling projects. This tutorial illustrates how these tools are used.

Prerequisite Tutorials

- MODLFOW 6 – Conceptual Model Approach
- MODFLOW – Building a Transient Model

Required Components

- GMS Core
- MODFLOW-USG Model & Interface

Time

- 15–30 minutes

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1 Introduction

This tutorial builds on the *MODFLOW – Building a Transient Model* tutorial. That tutorial demonstrates how to enter and import transient recharge and well pump data. This tutorial does not repeat that, but instead demonstrates how to create a transient MODFLOW 6 model given the transient conceptual model data.

This tutorial discusses and demonstrates opening a MODFLOW 6 model and solution, entering transient data, setting up stress periods and defining additional inputs, running MODFLOW, and reviewing the results.

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 and Saving the Project

To import the 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 *mf6_transient*\ directory and select “start.gpr”.
4. Click **Open** to import the project and close the *Open* dialog.

A MODFLOW 6 model with a solution and a set of map coverages should be visible (Figure 1). Two of the coverages are the source/sink and hydraulic conductivity coverages used to define the conceptual model. The third coverage is the recharge coverage.

Before continuing, save the project with a new name.

5. Select *File* | **Save As…** to bring up the *Save As* dialog.
6. Select “Project Files (*.gpr)” from the *Files of type* drop-down.
7. Enter **“**trans.gpr” and click **Save** to close the *Save As* dialog.

It is recommended to save the project periodically.

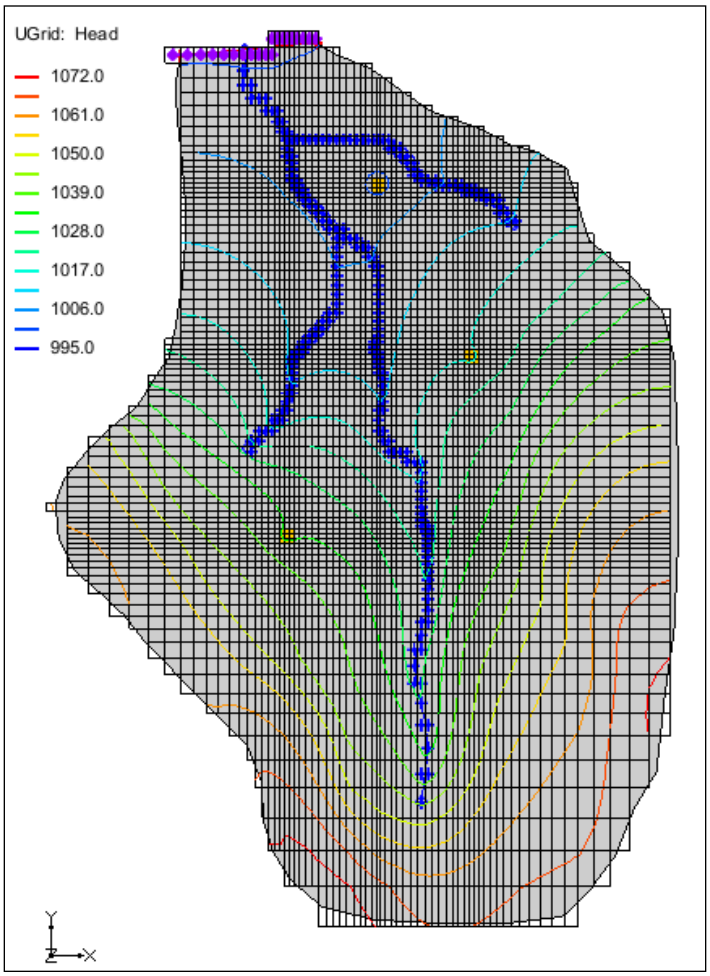

Figure 1 The initial project in the Graphics Window

3 Examining the Transient Conceptual Model

The initial transient data for the wells and recharge has already been included in the conceptual model. To see how to add this data to a conceptual model, see the *MODFLOW – Building a Transient Model* tutorial. Before continuing, review this transient data included with the wells in the conceptual model.

1. Right-click the "Sources & Sinks" coverage and select **Attribute Table** to open the *Attribute Table* dialog.
2. Make certain the *Feature type* is set to "Points", *Show* is set to "All", and *BC type* is set to "well".

See that the *Flow rate* column says "<transient>" for all the wells.

3. On the first well, click the button in the *Flow rate* column to open the *XY Series Editor*.

Notice that the pumping rate varies with time and the time is entered as dates/times, not just numbers.

4. Click **OK** to close the *XY Series Editor*.

5. Click **OK** to close the *Attribute Table* dialog.

Recharge is also time-varying. If desired, the *Attribute Table* for the "Recharge" coverage can be viewed following steps similar to those above. The rest of the data is constant, including the river, specified head, and hydraulic conductivity data.

4 Adding the STO Package

Transient models need to specify a storage coefficient. Since this is a one-layer unconfined aquifer, the specific yield needs to be assigned. The Storage (STO) package includes the specific yield. To add the STO package, complete the following:

1. Right-click on "flow" model and select *New Package* | **STO**.

The "STO" package will appear in the Project Explorer. The values for the STO package are defined in the conceptual model. The polygons in the "Hydraulic Conductivity" coverage contain the specific yield. To map those polygons to the STO package, complete the following:

2. Right-click the "STO" package and select **Map from Coverage** to bring up the *Select Coverage* dialog.
3. Select the "Hydraulic Conductivity" coverage.
4. Click **OK** to close the *Select Coverage* dialog.
5. Click **OK** to close the *Map from Coverage* dialog.
6. Double-click on the "STO" package to open the *Storage (STO) Package* dialog.
7. Select the *SY* tab.

Notice the specific yield data has been added.

8. Click **OK** to close the *Storage (STO) Package* dialog.

5 Adding Stress Periods to the TDIS Package

MODFLOW 6 discretizes time using stress periods and time steps. This project uses the Temporal Discretization (TDIS) package for discretization.

1. Right-click the "TDIS" package and select **Unlock**.
2. Right-click the "TDIS" package and select **Open…** to bring up the *Temporal Discretization (TDIS) Package* dialog.
3. Click **Add Rows…** to bring up the *Rows To Add* dialog.
4. Enter "7" for the Number of rows to add at bottom.
5. Click **OK** to close the *Rows To Add* dialog.

Eight stress periods are now in the *PERIODDATA* table.

6. In the *STEADY-STATE flow* column, make certain all the boxes past the first row are unchecked so that only the first row is checked on.

The steady-state versus transient information for each stress period is actually stored in the STO package, not the TDIS, but GMS presents it as a column in the TDIS package for convenience.

Continue with entering the remaining values for the *PERIODDATA* table.

7. From the table below, enter the *PERLEN* and *NSTP* values.

Row	PERLEN	NSTP
1	30.0	1
2	92.0	2
3	59.0	1
4	61.0	8
5	31.0	4
6	30.0	4
7	62.0	8
8	91.0	8

Next set the starting date and time by doing the following:

8. Under *Sections*, turn on *OPTIONS*.
9. Make sure *TIME_UNITS* is on and set to “DAYS”.
10. Turn on START_DATE_TIME.
11. In the *START_DATE_TIME* field, enter “9/1/1985”. Alternatively, the **Date/Time** button can be used to bring up a dialog where the date and time can be selected.

Notice the *ENDDATE* column now shows the ending date/time for the stress periods.

12. Click **OK** to exit the Temporal Discretization (TDIS) Package dialog.

6 Mapping the Recharge

Now to map the recharge values from the conceptual model over to the MODFLOW 6 simulation. To do this:

1. Right-click the “ RCH” package and select **Unlock**.
2. Right-click the “ RCH” package and select **Open…** to bring up the *Recharge (RCH) Package* dialog.
3. Select the *RECHARGE* tab.
4. Change the *Period* and notice that only the first stress period is defined.
5. Click **OK** to close the *Recharge (RCH) Package* dialog.
6. Right-click the “ RCH” package and select **Map from Coverage…** to open the *Select Coverage* dialog.
7. Select the “ Recharge” coverage.
8. Click **OK** to close the *Select Coverage* dialog and start the *Map from Coverage* dialog.
9. When finished, click **OK** to close the *Map from Coverage* dialog.
10. Right-click the “ RCH” package and select **Open…** to bring up the *Recharge (RCH) Package* dialog.

11. Select the *RECHARGE* tab.
12. Change the *Period* and notice that all seven stress periods have been defined.
13. Click **OK** to close the *Recharge (RCH) Package* dialog.

7 Mapping the Wells

The wells now need to be added to the MODFLOW 6 simulation.

1. Right-click the "WEL" package and select **Unlock**.
2. Right-click the "WEL" package and select **Open…** to bring up the *Well (WEL) Package* dialog.
3. Change the *Period* to "2" and notice that only the first period is defined.
4. Click **OK** to close the *Well (WEL) Package* dialog.
5. Right-click the "WEL" package and select **Map from Coverage…** to open the *Select Coverage* dialog.
6. Select the "Sources & Sinks" coverage.
7. Click **OK** to close the *Select Coverage* dialog and start the *Map from Coverage* dialog.
8. When finished, click **OK** to close the *Map from Coverage* dialog.
9. Right-click the "WEL" package and select **Open…** to bring up the *Well (WEL) Package* dialog.
10. Change the *Period* to "2" and notice that all wells have been defined for the second period and that *Q* values have been entered.
11. Repeat the previous step to view the other periods.
12. Select a cell in the *Q* column for any of the wells in any of the periods.
13. Click the **Plot All Periods** button to open the *XY Series Editor* dialog.

The *XY Series Editor* shows the pumping rate (Q) for the well for each stress period. If the XY series is edited here, the changes will be made in the *Well (WEL) Package* dialog.

14. Click **Cancel** to close the *XY Series Editor* dialog.
15. Click **Cancel** to close the *Well (WEL) Package* dialog.

8 Saving the Simulation

Before running the model simulation, the data needs to be saved out.

1. Click the **Save** macro to save the project.
2. In the Project Explorer, right-click on "sim" and select **Save Simulation**.

The files for the simulation have now been exported.

9 Checking the Simulation

Now check the simulation again before running MODFLOW 6.

1. In the Project Explorer, right-click on "sim" and select **Check Simulation** to bring up the *Check MODFLOW 6 Simulation* dialog.

There should be no errors.

2. Click **OK** to close the *Check MODFLOW 6 Simulation* dialog.

10 Running MODFLOW 6

It is now possible to run MODFLOW:

1. Right-click on "sim" and select **Run Simulation** to bring up a warning message.

Because a solution was already loaded into the project, this solution will have to be unloaded in order for MODFLOW 6 to run.

2. Click **OK** to close the warning dialog and start the *Simulation Run Queue* model wrapper dialog.

The *Simulation Run Queue* shows all simulation model runs currently in progress. Since this project only has one simulation, only one is shown.

3. When MODFLOW 6 finishes, click **Load Solution**.
4. Click **Close** to exit the *Simulation Run Queue* dialog.

11 Examining the Solution

Review the MODFLOW 6 solution with the transient values by doing the following:

1. Make sure the "Head" dataset is active in the Project Explorer.
2. Click **Display Options** to bring up the *Display Options* dialog.
3. Select "UGrid: UGrid – [Active]" from the list on the left.
4. Turn on Face contours and click **Options** to open the Dataset Contour Options– UGrid – Head dialog.
5. Change the *Contour method* to "Color Fill".
6. Click **OK** to close the Dataset Contour Options– UGrid – Head dialog.
7. Click **OK** to close the *Display Options* dialog.
8. Select different time steps to see how the solution varies with time.

12 Conclusion

This concludes the "MODFLOW 6 – Managing Transient Data" tutorial. The following topics were discussed and demonstrated:

- The steady-state versus transient information for each stress period is stored in the STO package but GMS displays it in the TDIS package for convenience.
- If the transient conceptual model uses absolute dates/times, the TDIS package must define the START_DATE_TIME and UNITS options.
- With list packages like WEL, an XY series plot of the values over time can be viewed and used to edit the data for a particular well.