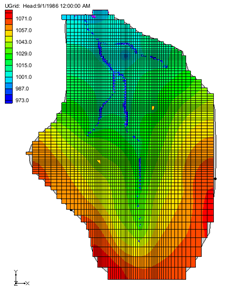
A picture containing shape

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GMS 10.9

GMS 10.9 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.

Time

* 15–30 minutes

Required Components

* GMS Core
* MODFLOW-USG Model & Interface

Prerequisite Tutorials

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

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# 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.

## 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.

# Importing and Saving the Project

To import the project:

1. Click **Open** File:Open Macro.svg 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.

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

It is recommended to save the project periodically.

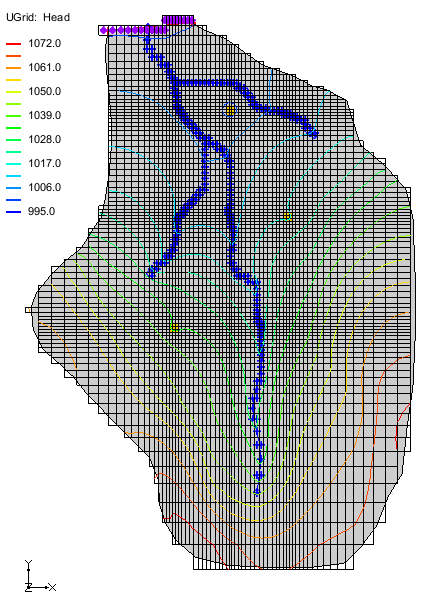


Figure The initial project in the Graphics Window

# 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 “File:Coverage Active Icon.svg 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”.

Notice that the *Flow rate* column says “<transient>” for all the wells.

1. On the first well, click the File:Attribute Table dialog dot dot dot ellipses button.png button in the *Flow rate* column to open the *XY Series Editor* dialog.

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

1. Click **OK** to close the *XY Series Editor* dialog.
2. Click **OK** to close the *Attribute Table* dialog.

Recharge is also time-varying. If desired, the *Attribute Table* for the “File:Coverage Active Icon.svg 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.

# 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 “File:Mf6package.svgSTO” package will appear in the Project Explorer. The values for the STO package are defined in the conceptual model. The polygons in the “File:Coverage Active Icon.svg Hydraulic Conductivity” coverage contain the specific yield. To map those polygons to the STO package, complete the following:

1. Right-click the “File:Mf6package.svgSTO” package and select **Map from Coverage…** to bring up the *Select Coverage* dialog.
2. Select the “File:Coverage Active Icon.svg Hydraulic Conductivity” coverage.
3. Click **OK** to close the *Select Coverage* dialog.
4. Click **OK** to close the *Map from Coverage* dialog.
5. Double-click on the “File:Mf6package.svgSTO” package to open the *Storage (STO) Package* dialog.
6. Select the *SY* tab.

Notice the specific yield data has been added.

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

# 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 “File:Mf6package.svgTDIS” package and select **Unlock**.
2. Right-click the “File:Mf6package.svgTDIS” 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. For the *Number of rows to add at bottom,* enter “7”.
5. Click **OK** to close the *Rows To Add* dialog.

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

1. 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.

1. 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:

1. Under *Sections*, turn on *OPTIONS*.
2. Make sure *TIME\_UNITS* is on and set to “DAYS”.
3. Turn on START\_DATE\_TIME.
4. 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.

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

# 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 “File:Mf6package.svgRCH” package and select **Unlock**.
2. Right-click the “File:Mf6package.svgRCH” 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 “File:Mf6package.svgRCH” package and select **Map from Coverage…** to open the *Select Coverage* dialog.
7. Select the “File:Coverage Active Icon.svg 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 “File:Mf6package.svgRCH” 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.

# Mapping the Wells

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

1. Right-click the “File:Mf6package.svgWEL” package and select **Unlock**.
2. Right-click the “File:Mf6package.svgWEL” 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 “File:Mf6package.svgWEL” package and select **Map from Coverage…** to open the *Select Coverage* dialog.
6. Select the “File:Coverage Active Icon.svg 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 “File:Mf6package.svgWEL” 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 **Plot All Periods** button to open the *XY Series Editor* dialog.

The *XY Series Editor* dialog 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.

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

# Saving the Simulation

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

1. Click the **Save** File:Save Macro.svg macro to save the project.
2. In the Project Explorer, right-click on “File:MODFLOW Folder.svg sim” and select **Save Simulation**.

The files for the simulation have now been exported.

# Checking the Simulation

Now check the simulation again before running MODFLOW 6.

1. In the Project Explorer, right-click on “File:MODFLOW Folder.svg sim” and select **Check Simulation…** to bring up the *Check MODFLOW 6 Simulation* dialog.

There should be no errors.

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

# Running MODFLOW 6

It is now possible to run MODFLOW:

1. Right-click on “File:MODFLOW Folder.svg 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.

1. 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.

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

# Examining the Solution

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

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

# 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.