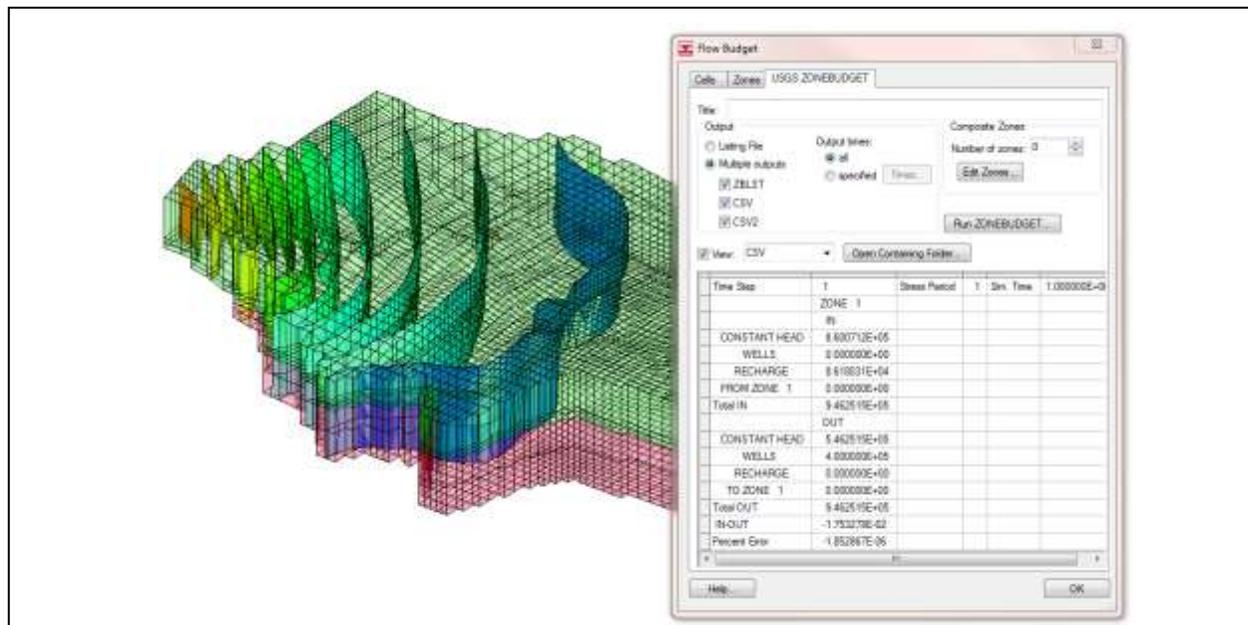


# GMS 10.0 Tutorial

## MODFLOW – ZONEBUDGET

Use ZONEBUDGET with a Multi-layer Model



### Objectives

Learn how to use ZONEBUDGET with MODFLOW in GMS.

### Prerequisite Tutorials

- MODFLOW - Grid Approach
- MODFLOW - Conceptual Model Approach I

### Required Components

- Grid Module
- Map Module
- MODFLOW
- Zonebudget

### Time

- 15-25 minutes



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# 1 Introduction

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ZONEBUDGET is USGS program that reads cell-to-cell flow data produced by MODFLOW and calculates water budgets for subregions of the modeled area.

This tutorial builds on the “MODFLOW – Grid Approach” and the “MODFLOW – Conceptual Model” tutorial. Those tutorials should be completed before this one. The purpose of this tutorial is not to teach the user all about ZONEBUDGET, but simply to demonstrate the ZONEBUDGET interface in GMS.

## 1.1 Outline

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Here are the steps of the tutorial:

1. Read an existing MODFLOW 2000 model.
2. Run ZONEBUDGET and view the outputs for a steady state MODFLOW solution.
3. Assign Zone Budget IDs to the model grid and run ZONEBUDGET.
4. Assign Zone Budget IDs using a conceptual model.
5. Run ZONEBUDGET on a transient MODFLOW solution.

# 2 Description of Problem

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The problem is the same model used in the “MODFLOW – Generating Data from Solids” tutorial. This is a multi-layer MODFLOW model of a site with complex stratigraphy. A cross section of the site is shown in the figure below.

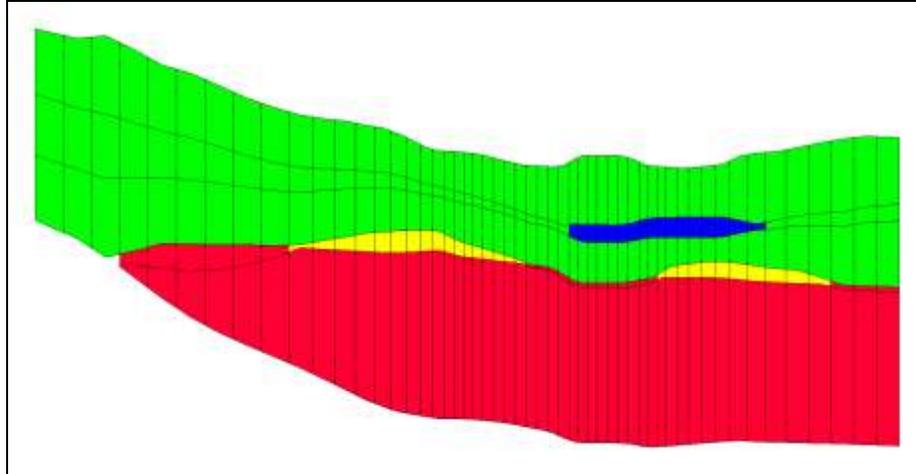


Figure 1 Multi-layer MODFLOW model

### 3 Getting Started

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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 Read in the MODFLOW 2000 Model

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First, it is necessary to read in an existing model:

1. Select the **Open**  button.
2. Locate and open the *Tutorials\MODFLOW\zonebudget* directory.
3. Select the file entitled “model.gpr.”
4. Click the **Open** button.

The user should see a MODFLOW model with color contours of the head solution.

### 5 Viewing the Flow Budget

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First, look at the flow budget for the MODFLOW model:

1. Select the *MODFLOW / Flow Budget* menu command.

The first tab that comes up in this dialog shows the flow budget for any selected cells or, if no cells are selected, then it shows the budget for the entire model domain. It is obvious that this model has flow into the model from constant head and recharge boundary conditions and flow out through constant head and well boundary conditions.

2. Select the *Zones* tab in the dialog.

This tab provides features similar to USGS ZONEBUDGET; it provides a more concise summary of the flow budget. However, the information displayed in this tab comes from GMS reading the MODFLOW cell-to-cell flow output file (\*.ccf).

## 6 Running ZONEBUDGET

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Now it is possible to run ZONEBUDGET and view the outputs. The user will run ZONEBUDGET from the USGS ZONEBUDGET tab in this dialog.

1. Select the *USGS ZONEBUDGET* tab.
2. Select the **Run ZONEBUDGET** button.

The *USGS ZONEBUDGET* dialog will appear, showing ZONEBUDGET while it runs.

3. Select the **Close** button when ZONEBUDGET has finished running.

Notice that the ZONEBUDGET output has been displayed in the dialog. This output is very similar to the output that was seen in the *Zones* tab. The user is currently viewing the CSV output from ZONEBUDGET. When the user ran ZONEBUDGET, two other output files were created. Under the Output section of the dialog, the user can see that ZBLST, CSV, and CSV2 outputs are selected under the *Multiple outputs* option.

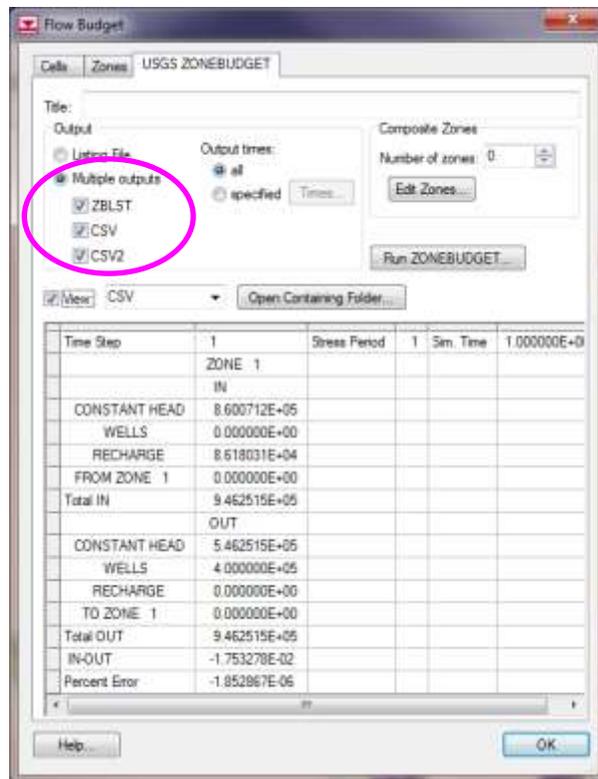


Figure 2 ZONEBUDGET dialog

- In the drop down list next to the *View* toggle, change the selection to “ZBLST.”

This is the ZONEBUDGET listing file. It provides information on the inputs to ZONEBUDGET as well as the outputs. Scroll to the end of the file to see a report similar to what was viewed with the CSV output file.

- Select the **Open Containing Folder** button.

Windows Explorer opens to the directory where all of the ZONEBUDGET inputs and outputs are stored. The files are in the same location as the MODFLOW ccf that is used in the ZONEBUDGET run. The following figure shows the ZONEBUDGET files.

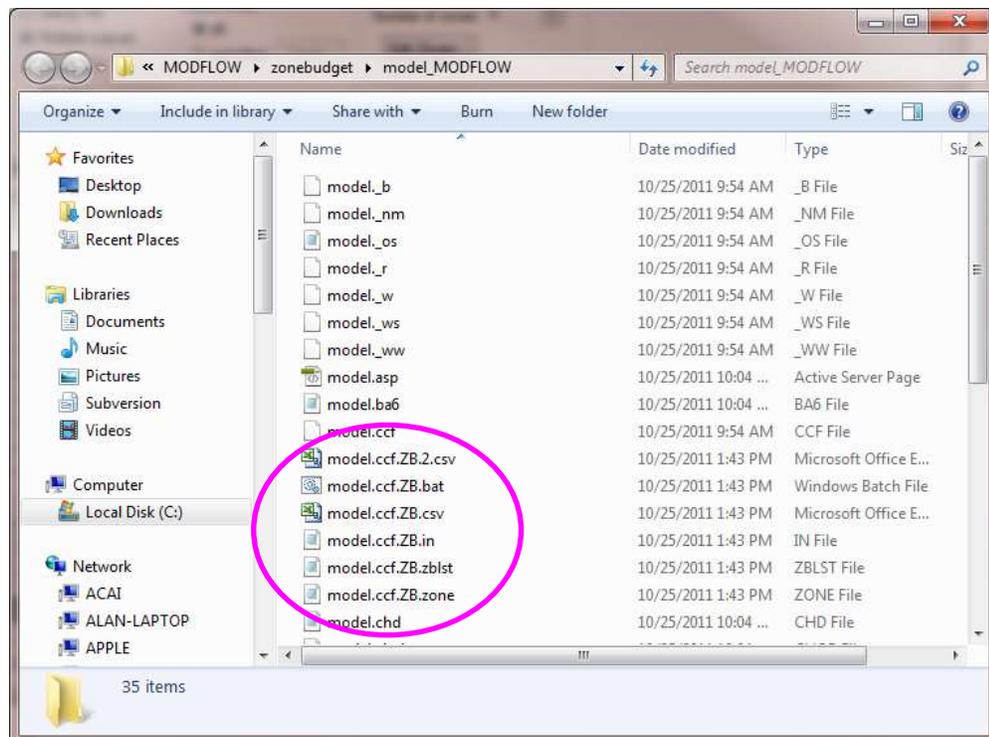


Figure 3 ZONEBUDGET input and output files

All of the ZONEBUDGET files have the name of the ccf file with the added .ZB to clearly identify the files. The .zblst, .csv, and .2.csv are the ZBLST, CSV, and CSV2 files respectively. The .in and .zone files are inputs to ZONEBUDGET. The .bat file is a Windows batch file that can be used to rerun ZONEBUDGET.

6. Close Windows Explorer and return to GMS.
7. Select **OK** to exit the dialog.

## 7 Assigning Zone Budget IDs

The next step is to assign different Zone budget IDs to the grid. When the user ran ZONEBUDGET previously, every cell in the model grid was assigned a Zone budget ID of 1. First, the user will assign different zone IDs to the layers of the grid.

1. Expand the items below “3D Grid Data” folder, the “grid” item, and the “MODFLOW” item in the Project Explorer so that the “Zone Budget IDs” item is visible.

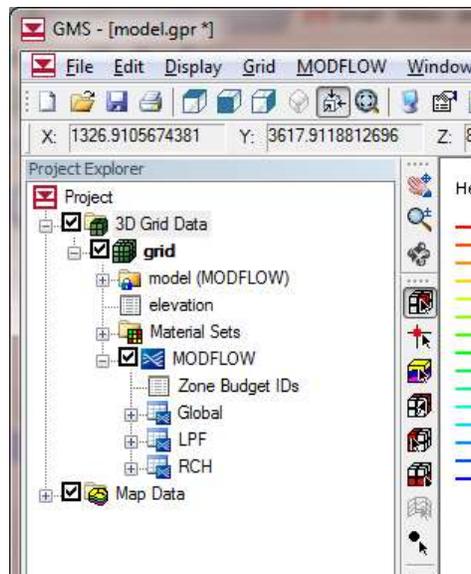


Figure 4 Expanded items in the Project Explorer

2. Right click on the “Zone Budget IDs”  item.
3. Select the **Properties** command.

This command brings up an array editor that can be used to edit the IDs. This is the same editor that is used to edit all array inputs to MODFLOW. The user is going to assign a different ID to each layer in the grid. The dialog is currently showing the IDs for layer 1.

4. In the *Zone Budget IDs* dialog, use the up arrow to change the *Layer* to “2.”

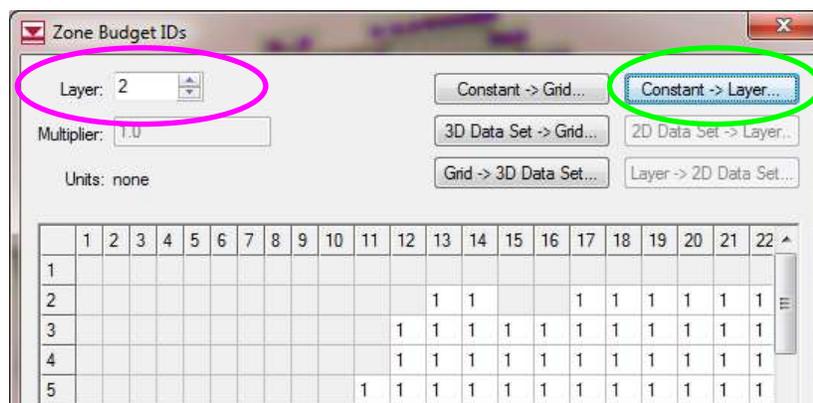


Figure 5 The Zone Budget IDs Editor

5. Select the **Constant → Layer** button.
6. In the *Layer Value* dialog, enter a value of “2” at the prompt, and select **OK**.
7. Repeat this process for layers 3, 4, and 5. Assign the layer number as the Zone Budget ID.

8. Select **OK** to exit the dialog.
9. In the Project Explorer, click on the “model (MODFLOW)”  item to make it active.

## 8 Running ZONEBUDGET

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The next step is to run ZONEBUDGET again.

1. Select the *MODFLOW* / **Flow Budget** menu command.
2. In the *Flow Budget* dialog, select the *USGS ZONEBUDGET* tab.
3. Select the **Run ZONEBUDGET** button.
4. Select the **Close** button when ZONEBUDGET has finished running.

Notice that, in addition to the information about flows from boundary conditions, the user now has information about the flows exchanged between zones.

5. Select “CSV2” in the drop-down box next to the *View* toggle.

The CSV2 output file contains the same information that the CSV output file contains, but it is formatted differently.

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

## 9 Assigning Zone Budget IDs from a Conceptual Model

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Next the user will assign Zone Budget IDs using coverages that are part of a conceptual model. The user will use polygons to assign Zone Budget IDs to different areas of the model grid.

1. Expand the items below the “Map Data”  folder in the Project Explorer.

The user should see several coverages. There are 5 coverages that will be used to assign Zone Budget IDs.

2. Select the “Zones\_layer\_2” coverage.
3. Change the current grid layer by changing the *Lay (k)* to “2” in the *Mini Grid Toolbar* at the top of the GMS window.

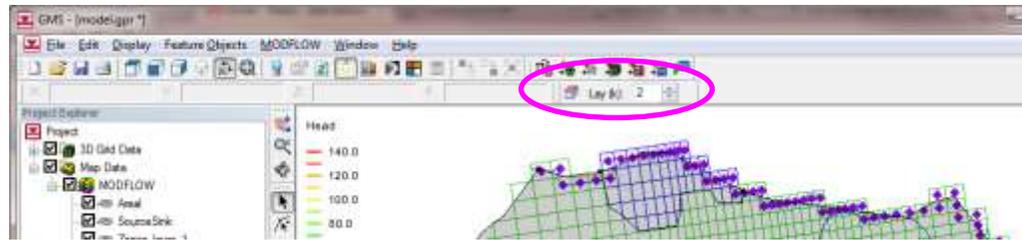


Figure 6 Mini Grid Toolbar

Notice that there are polygons that match with the different material zones (the color of the grid cells changes with the feature polygon boundaries). This model has 4 major material zones. Polygons have been created in the different coverages so that the user can assign IDs to these zones.

4. Double-click on the polygon that overlaps the blue material zone at the top of the model. In the *Attribute Table* dialog, notice that a *Zone budget ID* of 2 is assigned.
5. Select **OK** to exit the dialog.
6. Select the **Map → MODFLOW**  macro button.
7. In the *Map → Model* dialog, select **OK**.
8. The Zone Budget IDs have now been assigned to the grid.

## 10 Reading a Transient MODFLOW Solution

Before running ZONEBUDGET again, it is necessary to read in a transient MODFLOW solution.

1. Select the *MODFLOW / Read Solution* menu command.
2. Locate and open the *Tutorials\MODFLOW\zonebudget\trans\_MODFLOW* directory.
3. Select the file entitled “trans.mfn.”
4. Click the **Open** button.
5. Click on the “trans (MODFLOW)” folder to make it active.

Notice that “trans (MODFLOW)”  folder should now be the active solution in the Project Explorer. This means that when the user brings up the *Flow Budget* dialog, he or she will be looking at the CCF file associated with this solution. If the folder is not selected, select it to make it active.

## 11 Advanced ZONEBUDGET Options

The next step is to look at some of the advanced inputs to ZONEBUDGET.

1. Select the *MODFLOW / Flow Budget* menu command.
2. Select the *USGS ZONEBUDGET* tab.

Previously, when the user ran ZONEBUDGET, the model was steady state so there was only one time step in the CCF file. The current model solution comes from a transient model with multiple time steps. With ZONEBUDGET, the user can analyze all time steps or select specific time steps to analyze.

3. Select the *specified* option under the *Output times* section of the dialog. (See the next figure.)

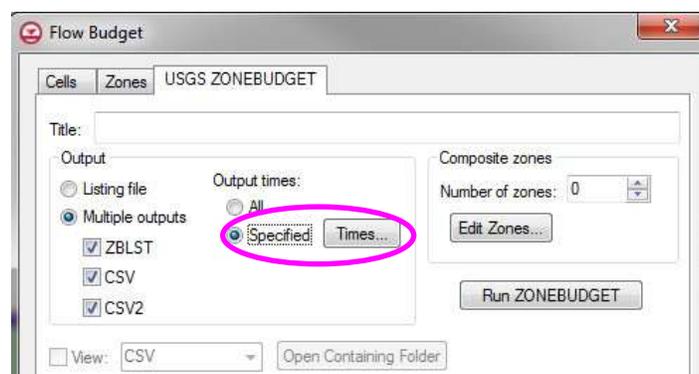


Figure 7 Specified output times

4. Click on the **Times** button.
5. In the *Properties* dialog, select the check boxes next to 300.0, 450.0, and 600.0.
6. Select **OK** to exit the dialog.

ZONEBUDGET also provides functionality to combine zones into Composite Zones. For example, in this problem, the user has zones 1, 2, 3, and 4. The user can make a composite zone comprising zones 1 and 2; then ZONEBUDGET will provide a report for zones 1, 2, 3, and 4 and for the composite zone.

7. In the *Composite Zones* section of the dialog change the *Number of Zones* to “2.”
8. Click on the **Edit Zones** button.
9. Fill in the spreadsheet as shown in the figure below.

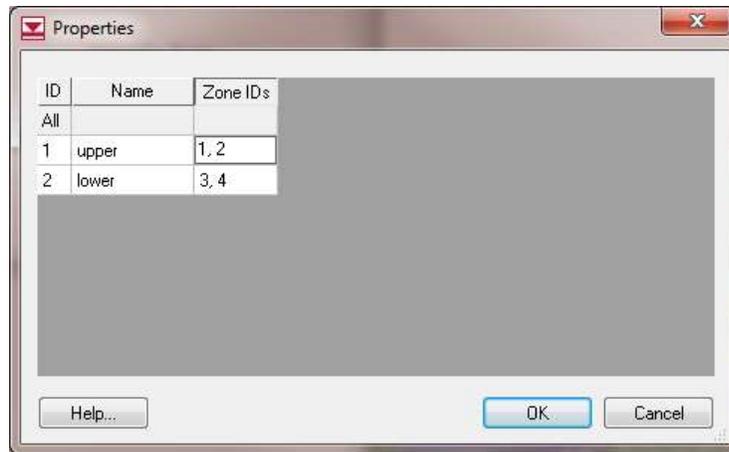


Figure 8 Composite zones

10. Select **OK** to exit the *Properties* dialog.

## 12 Running ZONEBUDGET

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1. Select the **Run ZONEBUDGET** button.
2. Select the **Close** button when ZONEBUDGET has finished running.

Notice that the output contains data from 3 different time steps. To view information about the composite zones, the user must look at the listing file (ZBLST).

3. Change the *View* to “ZBLST” and scroll to the bottom to see information on the “lower” composite zone.
4. Click **OK** to exit the *Flow Budget* dialog.

## 13 Conclusion

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

- GMS includes an interface to the USGS program ZONEBUDGET.
- It is possible to view ZONEBUDGET output in GMS.
- GMS supports all features of ZONEBUDGET.
- Zone Budget IDs can be assigned to the grid by manual means or by using the conceptual model approach.