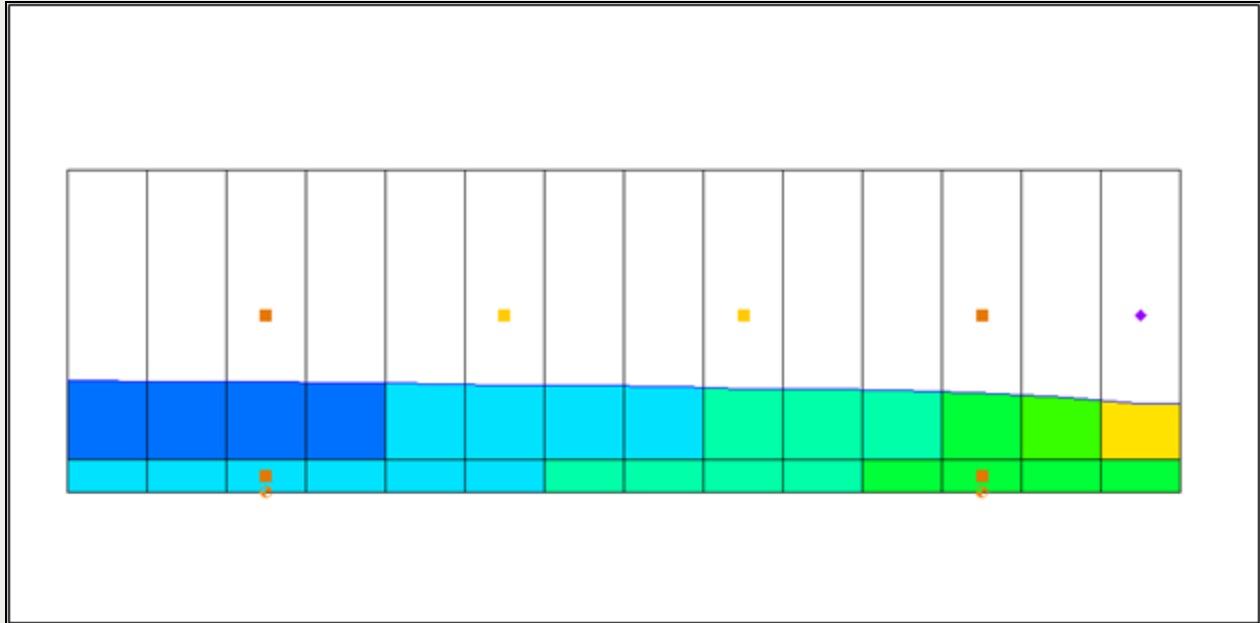




## GMS 10.9 Tutorial

### **MODFLOW-USG – CLN Observation Wells**

Create CLN well observations in GMS



### Objectives

Learn how to create CLN well observations using MODFLOW-USG and GMS.

#### Prerequisite Tutorials

- MODFLOW-USG CLN Process

#### Required Components

- GMS Core
- MODFLOW-USG Model & Interface

#### Time

- 20–30 minutes

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## 1 Introduction

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Head observations for CLN (Connected Linear Network) wells can be created to measure the computed head in a CLN node (cell). The process is similar to creating head observations in the groundwater domain, but with some key differences.

Creating a CLN observation well requires two steps:

1. Create a CLN well that is non-pumping.
2. Create an observation point that is linked to the CLN well and will be used by PEST to determine the head at the point.

An observation can be associated with a CLN well that is pumping (if you wanted to know the draw down at that well), but in general observation wells are not pumped.

### 1.1 Description of Problem

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The problem in this tutorial is the same simulation (Figure 1) described in the *MODFLOW-USG CLN Process* tutorial, but with simplified stress periods.

The system consists of two aquifers that are separated by a 50-foot-thick confining unit. In addition to the simulation of two multi-node wells (wells A and B) modeled using the CLN process, there are 15 other single-node wells modeled using the WEL package.<sup>1</sup>

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<sup>1</sup> K.J. Halford and R.T. Hanson. (2002). User Guide for the Drawdown-Limited, Multi-Node Well (MNW) Package for the U.S. Geological Survey's Modular Three-Dimensional Finite Difference Ground-Water Flow Model, Versions MODFLOW-96 and MODFLOW-2000. Open-File Report 02-293, pp15–17. [https://water.usgs.gov/nrp/gwsoftware/modflow2000/MNW\\_text.pdf](https://water.usgs.gov/nrp/gwsoftware/modflow2000/MNW_text.pdf).

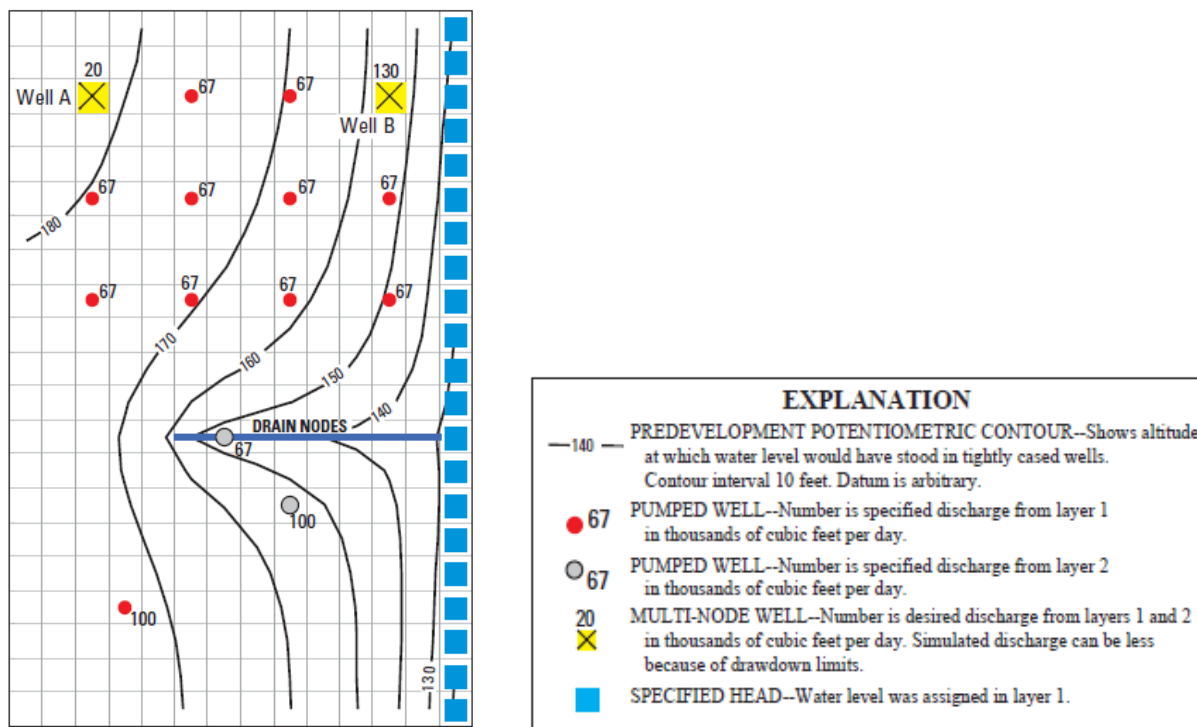


Figure 1 Flow model from MNW1 documentation<sup>2</sup>

## 1.2 Outline

This tutorial will demonstrate the following topics:

1. Opening an existing simulation that uses the CLN package.
2. Adding a CLN well and an observation point to the simulation using a conceptual model.
3. Running the simulation and examining the results.

## 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.
3. Click **Open** (or **File | Open...**) to bring up the *Open* dialog.
4. Browse to the *ClnObservation* directory and select "start.gpr".
5. Click **Open** to import the file and close the *Open* dialog.

<sup>2</sup> Ibid, p.16.

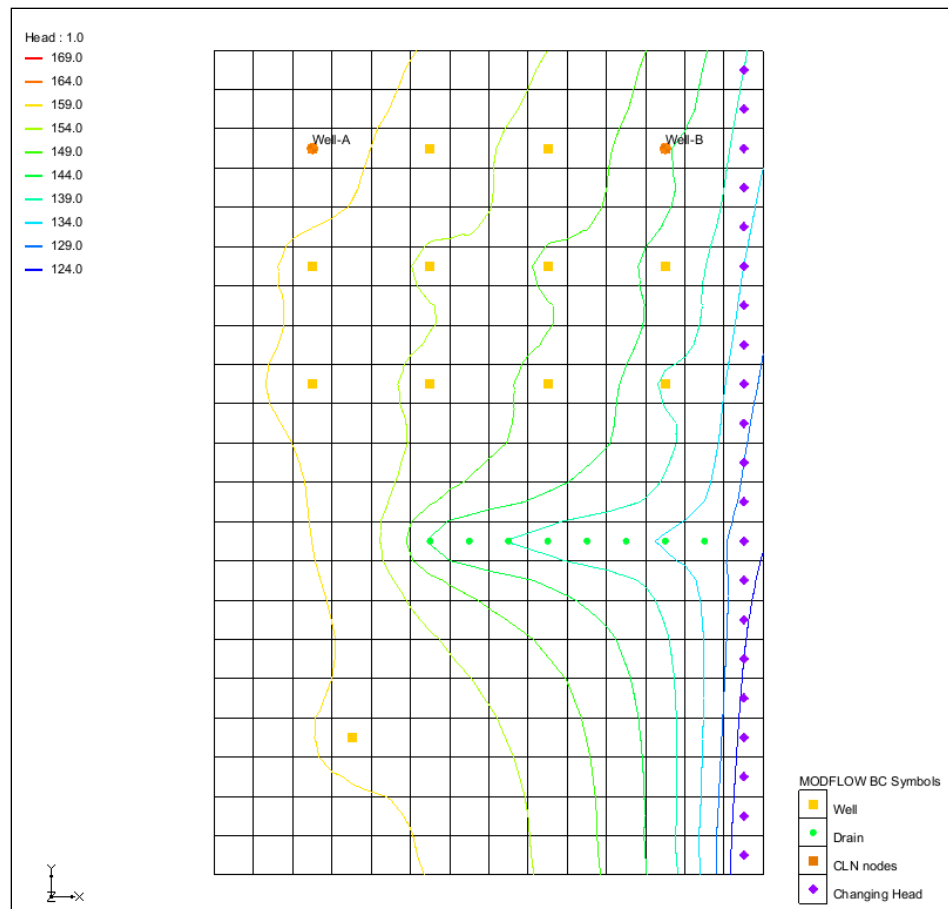


Figure 2 Imported CLN process example

The Graphics Window should appear as in Figure 2. This model has well, drain, and changing head (CHD) sources/sinks. In addition, the orange symbols in the upper left and right are the CLN nodes represented by Well-A and Well-B.

Before continuing, save the project with a new name.

6. Select **File** | **Save As...** to bring up the *Save As* dialog.
7. Browse to the *ClnObservations* directory.
8. For the *File name*, enter “ClnObservations.gpr”.
9. From the *Save as type* drop-down, select “Project Files (\*.gpr)”.
10. Click **Save** to save the project file and close the *Save As* dialog.

### 3 Creating the CLN Well

The first step is to create a non-pumping CLN well. The well will be created in the middle of the model (approximately).

1. In the Project Explorer, right-click on “CLN wells” and select **Attribute Table...** to open the *Attribute Table* dialog for this coverage.
2. Underneath the *Feature type*: drop-down, turn on *Show coordinates*.
3. Change the *BC type* to “ANY/NONE”.

4. The last row is blank. In the last row, enter the values on Table 1 below to create the observation well (Figure 3):

<b>Name</b>	Obs1
<b>X</b>	16700
<b>Y</b>	26300
<b>Z</b>	0
<b>Type</b>	well (CLN)
<b>Flow rate</b>	0
<b>Use screen</b>	<input checked="" type="checkbox"/> (on)
<b>Top scr.</b>	500
<b>Bot scr.</b>	0
<b>IFLIN</b>	<input type="checkbox"/> (off)
<b>IFCON</b>	Thiem with skin (1)
<b>FSKIN</b>	1
<b>FANISO</b>	1
<b>FRAD</b>	0.5
<b>CONDUITK</b>	43100000

Table 1 Observation well

Attribute Table

Feature type: Points Show: All BC type: well (CLN)

☒ Show coordinates

ID	Name	X	Y	Z	Type	Flow rate (ft <sup>3</sup> /d)	Use screen	Top screen
All								
1	Well-A	6250.0	46250.0	0.0	well (CLN)	<transient>	<input checked="" type="checkbox"/>	500.0
2	Well-B	28750.0	46250.0	0.0	well (CLN)	<transient>	<input checked="" type="checkbox"/>	500.0
3	Obs1	16700.0	26300.0	0.0	well (CLN)	0.0	<input checked="" type="checkbox"/>	500.0

Help... Add Point Delete Point

Figure 3 Observation well created using the Attribute Table dialog

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


A new well should appear in approximately the middle of the model. When a CLN well is created in the MODFLOW model, after mapping the coverage to MODFLOW, two things occur:

- CLN cells are created that are connected to the 3D groundwater cells
- A well is created in the lowest CLN cell


In this case a well screen from 500.0 to 0.0 will result in 2 CLN cells, one CLN cell for each layer in the grid and the CLN well will be placed in the CLN cell associated with layer 2.

## 4 Creating the Observation Point

The second step is to create the observation point that will be associated with the CLN cell where the CLN well “Obs1” is located. The observation point will be “linked” to the CLN cell by being in the same groundwater cell and by having the same name as the CLN well (in this case “Obs1”). The observation point does not need to be in the exact same location as the CLN well, but it can be. The computed head for this observation point will be the head in the CLN cell, not the groundwater cell nor the location of the observation point.

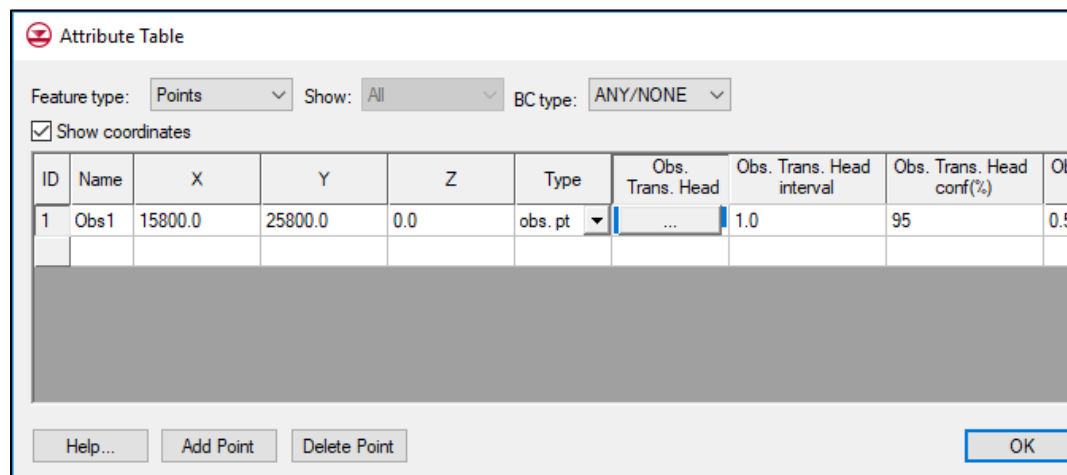
1. Right-click on “ CLN” in the Project Explorer and select **New Coverage...** to bring up the *Coverage Setup* dialog.
2. For the *Coverage name*, enter “Observations”.
3. In the *Observation Points* section, turn on “Trans. Head”.
4. Click **OK** to close the *Coverage Setup* dialog.

A new “ Observations” coverage will appear in the Project Explorer.

5. In the Project Explorer, right-click on “ Observations” and select **Attribute Table** to open the *Attributes Table* dialog for the coverage.
6. Underneath the *Feature type*: drop-down, turn on *Show coordinates*.
7. In the blank row, enter the values found in Table 2 below:


<b>Name</b>	Obs1
<b>X</b>	15800
<b>Y</b>	25800
<b>Z</b>	0
<b>Type</b>	obs.pt

Table 2 Observation point



ID	Name	X	Y	Z	Type	Obs. Trans. Head	Obs. Trans. Head interval	Obs. Trans. Head conf(%)	Obs
1	Obs1	15800.0	25800.0	0.0	obs.pt	...	1.0	95	0.3

Figure 4 Observation well created using the Attribute Table dialog

8. Click the  button in the *Obs. Trans. Head* column to open the *XY Series Editor*.
9. Enter the values in Table 3 below:

Time (d)	Obs. Trans. Head
10	152
500	148
900	159

Table 3 XY series values

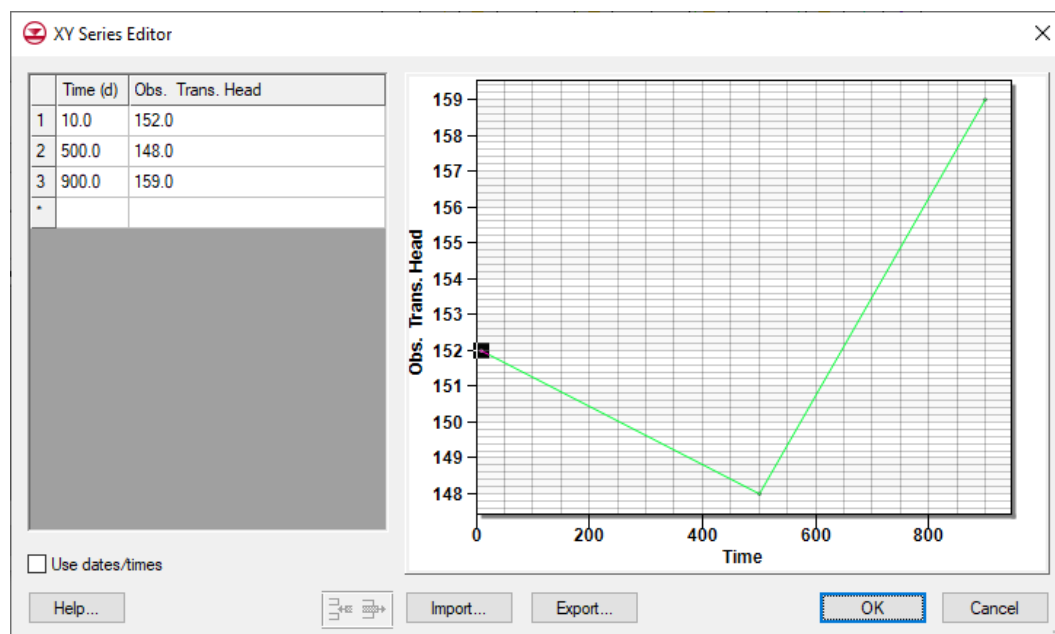


Figure 5 XY Series of the observed head values over time

10. Click **OK** to exit the XY Series Editor dialog.
11. Change the Obs. Trans. Head interval to "2.0".
12. Leave the remaining fields at the default values and click **OK** to exit the Attribute Table dialog.

## 5 Map to MODFLOW

The data added in the conceptual model needs to be mapped to the grid model.

1. Right-click on the "CLN" conceptual model and select **Map To | MODFLOW/MODPATH** to open the *Map → Model* dialog.
2. Check *All applicable coverages* and click **OK** to close the *Map → Model* dialog.

## 6 Review Model Inputs

The values mapped to the MODFLOW-USG simulation can now be viewed.

### 6.1 CLN WEL package

1. Select **MODFLOW | Optional Packages | CLN WEL – CLN Well...** to bring up the *MODFLOW CLN Wells Package* dialog.

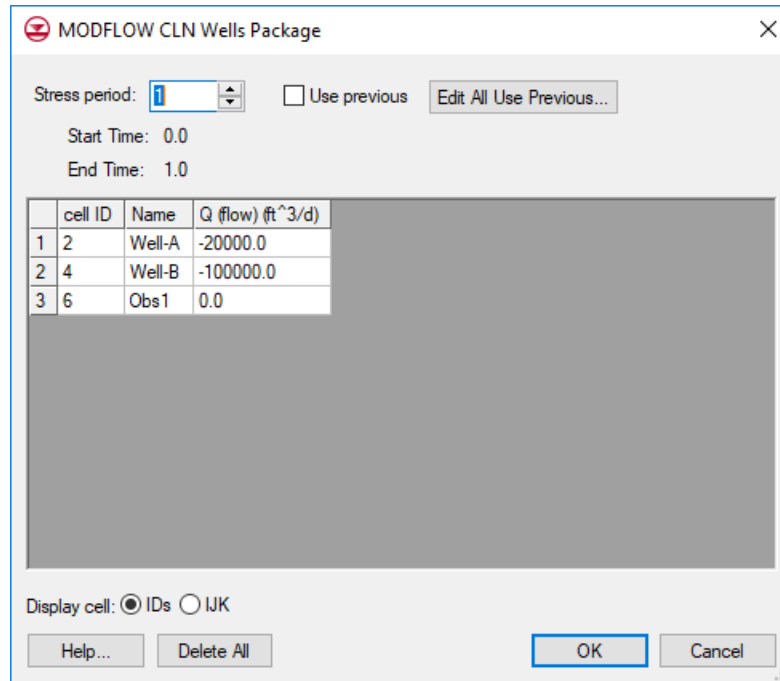


Figure 6 CLN Wells Package dialog

Notice the new Obs1 well appears and has a pumping rate of zero.

- Click **OK** to close *MODFLOW CLN Wells Package* dialog.

## 6.2 CLN – Connected Linear Network

- Select *MODFLOW | Optional Packages | CLN – Connected Linear Network...* to bring up the *CLN Process* dialog.
- From the list on the left, select “SegmentNodes”. A table will appear to the right of the list.

The CLN process contains nodes that can be connected together. For this simulation there are three CLN wells, and each well consists of two nodes. Each well has a unique *ClnSegmentId*, and each node has a unique *IFNO* value. Well-A is made up of the two nodes with a *ClnSegmentId* of “1”, and Well-B is made up of the two nodes with a *ClnSegmentId* of “2”. The new well, Obs1, is made up of the two nodes with a *ClnSegmentId* of “3”.

- From the list on the left, select “Nodes”. The table on the right will change to show node information.

This table shows the values for each CLN node.

- Click **OK** to close the *CLN Process* dialog.



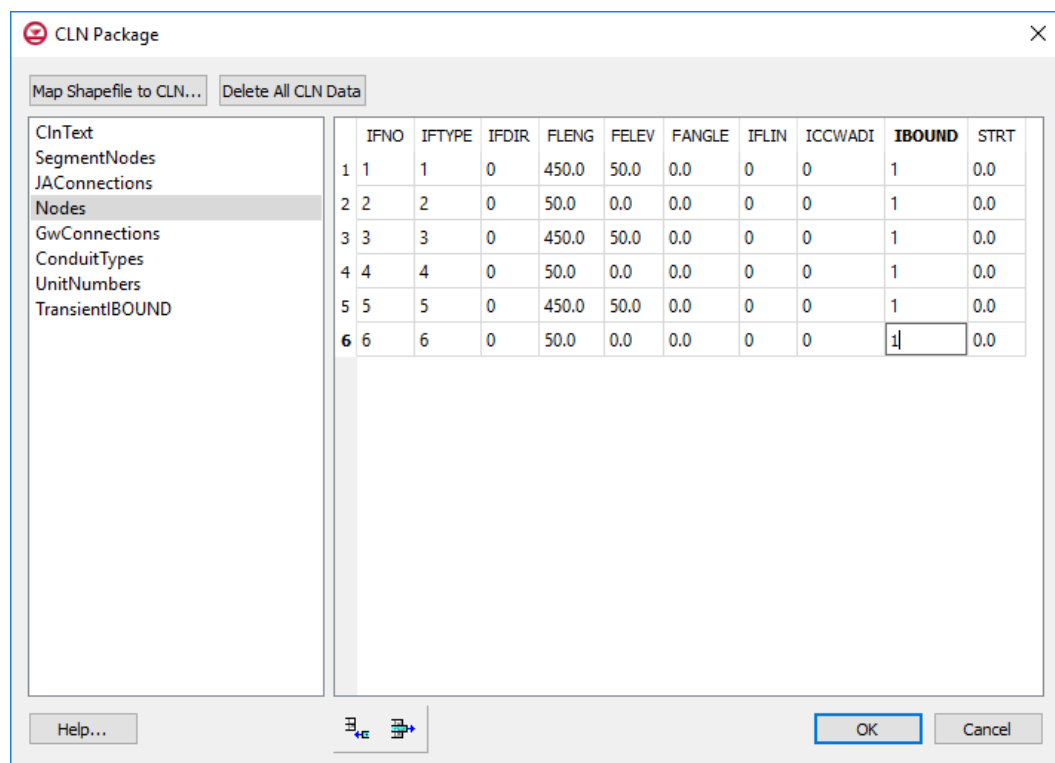


Figure 7 CLN Process dialog

### 6.3 Observations

1. Select **MODFLOW | Observations...** to bring up the *MODFLOW-USG Observations* dialog.

The *Observations* dialog shows the observation data that will be used with PEST utilities. Notice with “Wells” selected on the left, there is one well listed, the Obs1 well.

2. From the list on the left, select “Cln Well To Node”.

Notice there is one well listed, the Obs1 well, and the *Node ID* is the CLN node ID (6).



3. From the list on the left, select “Cln Well Sample”.


Notice the times and head observations are listed in the table.

4. Click **OK** to close the *MODFLOW-USG Observations* dialog.

## 7 Saving and Running MODFLOW

The changes should now be saved before running MODFLOW.

1. Click **Save**  to save the project.
2. Click the **Run MODFLOW**  macro in the toolbar to bring up the *MODFLOW* model wrapper dialog.
3. When MODFLOW finishes, check the *Read solution on exit* and *Turn on contours (if not on already)* boxes.
4. Click **Close** to close the *MODFLOW* model wrapper dialog.

5. Click **Save**  to save the project with the new solution.

The simulation should now appear as shown in Figure 8.

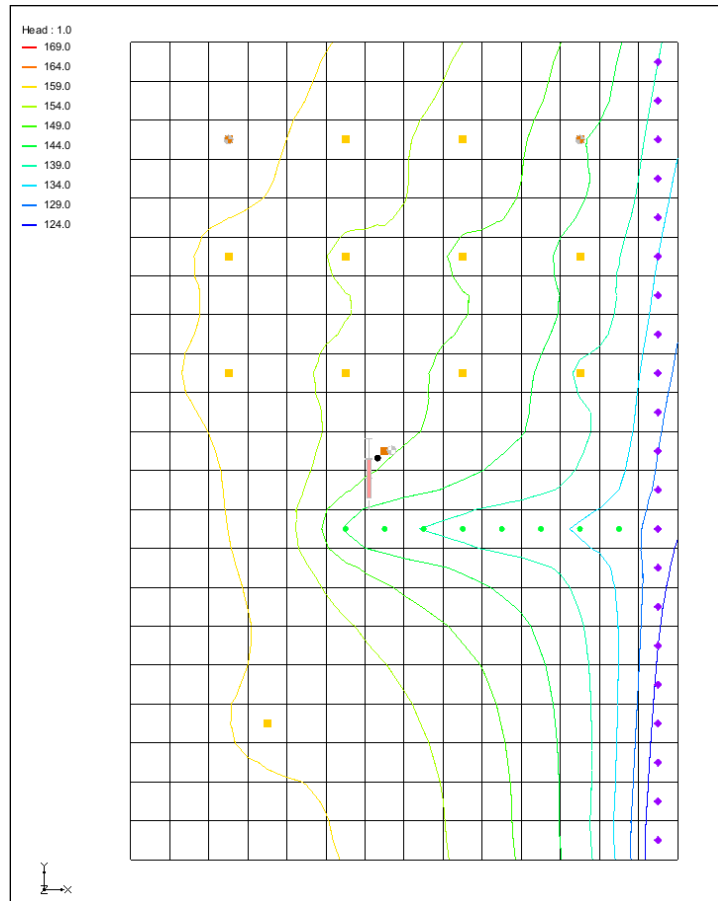


Figure 8 Solution with CLN observation well

## 8 Examining the Results

Examine the solution and compare it to the solution using the MNW2 package.

1. If necessary, expand the "ClnObservations (MODFLOW)" item in the Project Explorer.
2. In the "ClnObservations (MODFLOW)" folder select the "Head" dataset.
3. In the *Time Steps* window, use the down arrow key to step through the time steps and watch how the contours and the calibration target changes.

## 9 Changing the Observation or Well Name

To illustrate that the observation point name and the CLN well name must match for the observation to be linked to the CLN well:

1. In the Project Explorer, right-click on "Observations" and select **Attribute Table** to open the *Attribute Table* dialog for the coverage.

2. Change the *Name* to “Obs2”.
3. Click **OK** to close the *Attribute Table* dialog.

Notice that GMS provides a warning that the link between the observation point and the CLN well will be broken.

4. Click **Accept Changes** to close the warning dialog.

## 10 Conclusion

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This concludes the tutorial. Here are the key concepts from this tutorial:

- Head observations can be associated with CLN Wells.
- An observation point is “linked” to a CLN Well by being in the same 3D grid cell as the CLN Well and by having the same name.